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BEFORE THE
UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

IN RE APPLICATION FOR A FUEL ADDITIVE WAIVER FILED BY ETHYL CORPORATION UNDER § 211(f)(4) OF THE CLEAN AIR ACT	)

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July 12, 1991

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May 9, 1990

EXECUTIVE SUMMARY

Ethyl Corporation ("Ethyl") manufactures an automobile fuel additive under the trademark HiTEC® 3000. HiTEC® 3000 Performance Additive ("the Additive") is a manganese-based gasoline octane improver that is used in leaded gasoline in the United States and in all gasoline in Canada. Ethyl is filing this fuel additive waiver application with the Environmental Protection Agency ("EPA" or "Agency") to allow use of the Additive at a concentration of 0.03125 (1/32nd) gram of manganese per gallon in unleaded gasoline in the United States.

This application contains the results of an extensive research and testing program that shows that the Additive meets the legal standard for approval of a fuel additive waiver -- that it does not cause or contribute to the failure of emission control systems over their useful lives to meet emission standards for which they have been certified. Further, the application shows that the Additive has a positive environmental impact since it reduces total emissions of regulated pollutants, presents no risk to human health and has significant economic and energy benefits.

I. THE EMISSIONS TEST PROGRAM AND DATA ANALYSIS

Congress, in the Clean Air Act (the "Act"), recognized that "special emphasis" should be given to the development of fuels and fuel additives "which, when used, result in decreased atmospheric emissions." 42 U.S.C. § 7404(a)(1)(E). To ensure that new fuel additives would be adequately tested, Congress required that any new additive be shown not to cause or contribute to the failure of emission control devices or systems to meet applicable emission standards before being introduced for commercial use. 42 U.S.C. § 7545(f)(4).

Given this standard, Ethyl initiated a comprehensive testing and analysis program designed to assess the effect of the Additive on exhaust emissions, vehicle performance and driveability and materials used in fuel and emission control systems. Additional studies were done to quantify the impact of the Additive on refinery emissions and economics. In all, this has been the most extensive evaluation of a fuel additive ever undertaken by a private company.

The core of the program is a 48-car test fleet, designed in consultation with EPA and the automotive industry. Ethyl compared exhaust emissions at 5,000-mile intervals up to 75,000 miles from paired sets of vehicles fueled on clear fuel and fuel containing the Additive. These emissions data were then subjected to rigorous statistical analyses to determine the effect of the Additive on exhaust emissions and vehicle performance.

A. <u>Reductions in Exhaust Emissions</u>

These analyses confirm that the Additive causes a significant reduction in overall vehicle emissions, by as much as 1.62 billion pounds per year based on projections for 1999. Carbon monoxide (CO) emissions are reduced (an average of 0.22 grams per mile ("gpm") over 75,000 miles) and nitrogen oxide

(NOx) emissions are reduced significantly (an average of 0.11 gpm over 75,000 miles). While the test results show a very small but detectable increase in hydrocarbon (HC) emissions (an average of 0.010 to 0.018 gpm over 75,000 miles, depending upon how the data are interpreted), this is mitigated by two factors. First, the Additive raises octane (by about 0.9 octane numbers for unleaded gasoline). Therefore, its use would allow the refiner to exclude other octane-producing components normally included in the gasoline blend which contribute not only to HC emissions but also to fuel volatility and to emissions of other pollutants. This tradeoff, which would likely occur in the commercial market but was not included in the test protocol, would reduce or eliminate the very small HC increase observed in the test data.

Second, and more important, even without this adjustment, rigorous statistical analyses in accordance with EPA guidance and prior fuel additive waiver decisions show that the Additive meets the legal requirements contained in the Clean Air Act for a fuel additive waiver. In the words of independent statistical experts retained by Ethyl, "the results of the prescribed EPA tests convincingly demonstrate that the use of HiTEC 3000 in unleaded gasoline will not cause or contribute to the failure of any emission control system to meet emission standards for which it was designed." This conclusion is the same both for the 50,000 miles of vehicle operation required by EPA for waiver applications, and for extended mileage accumulation up to 75,000 miles. The test program is described in Appendix 1 to the waiver application, and the statistical analyses of the results are described in detail in Appendix 2.

B. Vehicle Performance

Ethyl undertook a number of test programs to examine the effect of the Additive on emission control devices, overall vehicle performance and other factors. These programs included evaluation of the Additive's effect on: (1) the components of emission control devices in the test fleet at the end of 50,000 miles and 75,000 miles of vehicle operation; (2) vehicle and emission control system durability following high-speed mileage accumulation; (3) emission control system durability following long-term (100,000 mile plus) mileage accumulation; and (4) automotive materials, evaporative emissions and vehicle driveability. These additional programs show that the Additive does not adversely affect vehicle and control system durability, the materials used in fuel and emission control systems, vehicle driveability or evaporative emissions. These tests are described in detail in Appendix 3 to the waiver application.

C. Compliance with Future Emission Control Standards

In view of current congressional consideration of stricter emission standards, Ethyl took the added step of analyzing the emission data from the 48-car test program to determine whether the Additive would cause or contribute to the failure of emission control devices or systems to meet stricter emission standards. Ethyl applied these potential emission standards to those test fleet vehicles which met the current HC emission standard using existing emission control technology. The results showed that use of the Additive would not cause or contribute to the failure of emission control systems to meet these stricter emission standards. In fact, the Additive's use would make it easier to achieve stricter NOx and CO emission standards. While this analysis is not legally necessary (§ 211(f)(4) is only concerned with the first introduction of a fuel additive into commerce), it provides an additional measure of confidence that use of the Additive will not harm the public health or the environment.

II. <u>OTHER ENVIRONMENTAL, ECONOMIC AND ENERGY BENEFITS</u>

The Additive is a proven fuel additive, with production and distribution systems already in place. It has been used extensively and without problem in fuels for catalyst equipped automobiles in Canada for many years. It is also compatible with and produces equivalent benefits (e.g., octane improvement and reduced total regulated tailpipe emissions) in oxygenated and other reformulated fuels, which are currently available or are being studied by the oil and auto industries for possible use. For these reasons, the benefits associated with the Additive are quickly and economically available. Moreover, the benefits are safely obtainable because manganese, an element essential to life, has been shown through studies to pose no health risk from the trace amounts emitted when using the Additive at the proposed concentration.

A. <u>Environmental Improvements in Refinery Operations</u>

Because it enhances octane, use of the Additive would allow refiners to reduce the severity with which they process crude oil. Reduced severity produces a number of beneficial results which were examined in detail and quantified by Turner, Mason & Company, a recognized expert in refinery operations. First, reduced refining severity would cause annual refinery emissions to decrease by up to 11 million pounds for NOx, up to 3 million pounds for CO, up to 1.1 million pounds for particulates, up to 150,000 pounds for sulfur dioxide, and up to 10 billion pounds for CO_2. These emission reductions would be in addition to the substantial automotive emission reductions demonstrated by the test program.

Second, the octane-enhancing effect of the Additive would result in refineries reducing the level of aromatics in gasoline. Turner, Mason estimates that the average aromatic content of gasoline could be decreased by as much as 4 percent from current levels (from 31.2 to 30 percentage points of the fuel by volume), and the benzene content of gasoline could be decreased by up to 6 percent (from 1.7 to 1.6 percentage points of the fuel by volume) without sacrificing octane. In addition, based on chemical speciation testing of automotive exhaust emissions, use of the Additive to enhance octane in place of aromatics could futher reduce automotive emissions of reactive volatile compounds and emissions of other noxious air pollutants, such as benzene and formaldehyde, which are increasingly under scrutiny as cancer-causing agents.

Finally, when refining gasoline from crude oil, highly volatile materials such as butanes are produced. Although butane enhances octane, it also raises gasoline vapor pressure. Gasoline with a high vapor pressure can contribute to increased evaporative and running emissions from vehicles in hot weather. Because the Additive enhances the octane of unleaded gasoline by about one octane number, less butane is produced in the refining process when using the Additive. This reduced refining severity makes it easier for refiners to meet lower vapor pressure specifications for gasoline, and thereby ultimately further reduces automotive emissions.

B. Positive Economic and Energy Impacts

By allowing the refineries to operate under less severe conditions without sacrificing the octane rating of gasoline, use of the Additive could result in a reduction in crude oil imports of about 30 million barrels per year. At $18 per barrel, this amounts to a reduction in imports of nearly $540 million per year. This savings would nearly replace the amount of oil stored each day in the U.S. Strategic Petroleum Reserve. Similarly, use of the Additive would allow refiners to reduce investment in equipment for enhancing octane through the refinery process by nearly $750 million.

C. Reductions in Ambient Concentrations of Other Air Pollutants

The reductions in mobile and stationary source emissions associated with use of the Additive would have a corresponding beneficial impact on ambient concentrations of, and population exposure to, regulated pollutants. Since ozone ambient concentrations are influenced by both reactive HC and NOx emissions, use of the Additive could result in small reductions in ozone concentrations in certain urban areas. Use of the Additive could also marginally improve ambient concentrations of NO_2, CO and benzene. These positive impacts are described in detail in Appendix 5. The environmental and health considerations associated with use of the Additive are discussed more generally in Appendix 8. In summary, numerous studies and 12 years of widespread use in Canada have demonstrated that the Additive has no adverse health or environmental impact.

III. CONCLUSION

The exhaustive testing and statistical analyses performed by Ethyl, and described in detail in this waiver application and supporting appendices, demonstrate that the Additive meets the statutory standard for approval of a fuel additive waiver. In addition, its use in unleaded gasoline will result in substantial environmental, economic and energy benefits. As a result, the Additive is a timely and desirable addition to the array of options for improving air quality. For these reasons, Ethyl requests prompt approval of this application.

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I. INTRODUCTION

This waiver application is being filed by Ethyl Corporation ("Ethyl") pursuant to § 211(f)(4) of the Clean Air Act ("CAA" or "Act"), 42 U.S.C. § 7401 et seq. Ethyl seeks a waiver for its HiTEC® 3000 Performance Additive ("the Additive" or "the HiTEC 3000 additive") when used in a concentration not to exceed 0.03125 grams manganese as HiTEC 3000 per gallon (approximately 8 mg/liter) of unleaded gasoline.[1/] The chief benefit of the Additive is its octane-enhancing properties. The addition of about one-half teaspoon of the Additive in a 20-gallon tank of unleaded gasoline improves the octane number of the gasoline by approximately one octane number. This increase is achieved at approximately one-third the cost of the currently available alternatives for enhancing octane.

As required under § 211(f)(4) of the Act, this application demonstrates that use of the Additive, in the concentration specified, will not cause or contribute to the failure of emission control devices or systems to meet applicable emission standards. In the sections that follow, Ethyl presents the

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[1/] HiTEC® is a registered trademark of the Ethyl Corporation. For simplicity, "the Additive" or "HiTEC 3000" will be used throughout this document to refer to the HiTEC® 3000 Performance Additive. The chemical name for the Additive is methylcyclopentadienyl manganese tricarbonyl. The Additive is also know under the name "MMT."

results of an extensive mobile source test program, designed in consultation with the U.S. Environmental Protection Agency ("EPA" or "Agency"), regarding the effects of the HiTEC 3000 additive on automobile emissions of nitrogen oxides ("NOx"), carbon monoxide ("CO") and hydrocarbons ("HC").

Analysis of these data using both statistical methods long applied by the Agency in evaluating waiver applications and other statistical tests, shows that the Additive will not cause or contribute to the failure of emission control devices. Indeed, these analyses show that the Additive will reduce overall tailpipe emissions. For the first 50,000 miles of operation in the test program, total emissions of NOx, CO, and HC from the test vehicles fell on average from 3.59 grams per mile ("gpm") using clear fuel to 3.45 gpm when using the Additive. NOx emissions dropped on average about 0.07 gpm. CO emissions registered an average reduction of about 0.09 gpm. Over 75,000 miles of vehicle operation, total emissions fell even further, from 4.14 gpm on average using clear fuel to 3.82 gpm when using the Additive.[2/]

These reductions in the emissions of NOx and CO can be achieved with little, or no, change in HC emissions. While HC

[2/] The emission numbers in the paragraph above are based on the analysis of data set Ethyl4S2, the most conservative of the data sets analyzed (i.e., the data set the analysis of which results in the smallest estimate of net pollutant reductions). See Appendix 2A, at D-25 to D-27. As a result, actual emission reductions could be even greater. See infra note 24.

emissions increased slightly for the test fleet vehicles using the Additive compared to those using clear fuel (on average, 0.018 gpm for the first 50,000 miles of operation, and as little as 0.010 gpm over 75,000 miles), this small increase, discussed in greater detail below, did not cause non-compliance with the HC emission standard. Nor is such an increase likely to occur in commercial operation.

In the test program, the addition of the Additive to the clear test fuel raised the octane rating of the Additive blend above that of the clear test fuel. This is important because additional testing by Ethyl shows that the HC emissions associated with use of the Additive do not increase -- and may, in fact, be less -- when a fuel containing the Additive is compared to a fuel to which aromatics have been added to equalize the octane ratings of the test fuels. In commercial operation, the octane-boosting properties of the Additive will allow refiners to reformulate unleaded gasolines containing the Additive, without sacrificing octane, by <u>reducing</u> the aromatic content of the fuel. This, in turn, would reduce HC tailpipe emissions, as has been demonstrated in several independent studies.

This waiver application also presents the results of further test programs designed to examine the effect of the Additive on automotive materials, driveability, and other key parameters. Analyses of the additional data developed through these programs show that the Additive will not adversely affect evaporative emissions, materials used in automotive fuel and emission systems, or vehicle driveability.

In addition, this application describes other environmental, economic and energy effects associated with the use of the Additive. Among other things, these analyses show that the Additive will (1) reduce emissions of NOx, CO and other pollutants from refineries; (2) have a positive impact on ambient concentrations of NOx, CO and toxic pollutants such as benzene; (3) have a generally neutral, although in some ways beneficial, effect on ambient ozone concentrations; (4) reduce emissions of volatile compounds such as benzene from mobile sources; and (5) reduce the demand for imported oil, contributing positively to this nation's balance of payments.

Finally, Ethyl demonstrates that the Additive will not adversely affect human health or the environment. These and other issues relevant to the use of the Additive are discussed in more detail below.

II. THE HiTEC 3000 ADDITIVE WILL NOT CAUSE OR CONTRIBUTE TO THE FAILURE OF EMISSION CONTROL DEVICES OR SYSTEMS TO MEET APPLICABLE EMISSION STANDARDS.

The Additive has a long history of safe use in this country and Canada as a performance fuel additive. To address the effect of the Additive on automobile exhaust emissions in the United States, Ethyl developed the most extensive, comprehensive and costly emissions testing program of a fuel additive ever undertaken by a private company. Ethyl has subjected the results of this extensive data collection program to rigorous statistical analyses by two independent groups of statisticians. The results of this comprehensive program, discussed below and in the appendices to this waiver application, affirmatively establish that the Additive will not cause or contribute to the failure of emission control devices or systems to meet applicable emission standards.[3]

A. The History of the HiTEC 3000 Additive

1. Development and Historical Use

The Additive is an octane improver developed by Ethyl scientists more than 35 years ago. Since that time, it has been used continuously in leaded gasoline and, for several years in the early 1970's, in unleaded gasoline in the United States. In Canada, it has been used in leaded and unleaded gasoline for more than 10 years. To date, several hundred billion miles of vehicle service have been accumulated on unleaded gasoline containing the Additive.

As noted, the chief advantage of the Additive is that it enhances octane at a cost substantially less than that of other available octane-enhancing methods. Raising octane by one octane number using the Additive costs approximately 8 to 12 cents, while an equivalent octane increase achieved through additional refinery processing costs 30 to 60 cents.[4] The Additive thus

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[3] For a more detailed discussion of the legal standard applicable to waiver applications under § 211(f) of the CAA, see infra pp. 39-45.

[4] Appendix 6, Attachment 6-1, at Table 11.

has a clear cost advantage over alternative methods of enhancing octane.

Because of this cost advantage, use of the Additive in the United States steadily increased until 1977, when nearly 60 percent of the unleaded gasoline contained the Additive. Because of its widespread use at that time, the EPA issued a notice in 1977 requiring that the Additive be used in the emission certification test gasolines for 1979 model cars.[5/] Thereafter, the automobile industry, Ethyl and others initiated test programs to better determine the overall performance and emissions characteristics of cars operated on unleaded gasolines containing the HiTEC 3000 additive.[6/]

Prior to completion of this testing, EPA acted on a waiver application filed by Ethyl in 1978 under § 211(f)(4) of the Act.[7/] Based primarily on the lack of an adequate data base upon

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5/ See Mobile Source Air Pollution Control Advisory Circular 26-B, U.S. Environmental Protection Agency, Office of Air and Waste Management, January 7, 1977.

6/ Several automobile manufacturers, oil companies and Ethyl agreed in 1977 to sponsor a 50,000 mile test of sixty-three 1977 and 1978 cars to consider whether the use of the Additive in unleaded fuel at concentrations of 0.0625 and 0.03125 grams manganese/gallon (approximately 16 mg/liter and 8 mg/liter), respectively, would affect exhaust emissions on automobiles designed to meet California emission standards.

7/ The 1977 amendments to the CAA prohibited manufacturers of fuel additives from distributing for use after September 15, 1978 any fuel additives which were not substantially similar to fuel additives used in the certification of automobiles for the 1975, or any subsequent, model year. See 42 U.S.C. § 7545(f)(3). For this reason, Ethyl filed the 1978 waiver application to allow use of the HiTEC 3000 additive in unleaded gasoline, even though the (continued...)

which to make a decision, EPA found that Ethyl had not met its burden of showing that the Additive would not cause or contribute to a failure of emission control devices or systems to meet applicable emission standards, and denied Ethyl's waiver application on September 11, 1978.[8/] The Agency acknowledged, however, that Ethyl was "free to reapply for a waiver whenever it believes new data justify such reapplication."[9/]

[7/] (...continued)
Additive had been widely used since 1974. There is no federal restriction on use of the Additive in <u>leaded</u> fuels.

[8/] <u>See</u> In Re Application for MMT Waiver, Decision of Administrator, No. MSED-211(f) (September 11, 1978) (hereinafter "1978 Waiver Decision").

[9/] <u>Id</u>. at 5. Other than the potential effect on HC emissions, EPA concluded that the use of the Additive did not adversely affect CO or NOx emissions. Characterization Report: Analysis of MMT Fleet Data to Characterize the Impact of MMT on Tailpipe Emissions, Technical Support Branch, Mobile Source Enforcement Division, Office of Mobile Source and Noise Enforcement, United States Environmental Protection Agency, at 2 (September 1978) (hereinafter "Characterization Report").

Ethyl also filed a waiver application for the Additive in 1981, which was based on an extrapolation from the data considered in the 1978 waiver proceeding. In contrast to the 1978 waiver application, which relied on actual emissions test data, the 1981 waiver application used a mathematical model to theoretically "predict" the effect of using the HiTEC 3000 additive at a concentration of 0.015625 grams per gallon (gpg) based on the effect shown by emissions testing using the Additive at concentrations of 0.0625 gpg and 0.03125 gpg. The Agency concluded that the results generated by this mathematical model were not "reasonable" because they were inconsistent with most of the test data from the earlier waiver proceeding, and because no experimental testing had been completed to actually measure the emissions effect, if any, when using the Additive at a concentration of 0.015625 gpg. <u>See</u> Denial of Application for a Fuel Waiver Submitted by the Ethyl Corporation, EN-81-15 (November 20, 1981). Again, however, the Agency invited Ethyl to "reapply for a waiver in the event that additional data are developed." <u>Id</u>. at 10.

2. Developments During the 1980s

Considerable changes in automotive technology have occurred since 1978. In the 1978 test program, for example, approximately 80 percent of the vehicles tested were equipped with conventional oxidation catalyst systems. Although this type of catalyst proved successful in oxidizing HC and CO emissions (or in a reduction type, reducing NOx emissions), tighter emission controls on these pollutants forced the development and use of three-way catalytic converters. In addition, only 20 percent of the 1978 test fleet had fuel-injection systems.

Since 1981, by comparison, essentially all newly manufactured automobiles have been equipped with three-way catalyst systems.[10/] Moreover, since 1985, essentially all new vehicles have been equipped with fuel-injection systems. In light of these developments in automotive technology, Ethyl approached EPA in 1987 to discuss designing a new test program to evaluate the impact of the Additive on emission control devices.[11/]

10/ See Appendix 7, at 3.

11/ In addition to the dramatic changes in emission control technology since 1978, there is another reason why Ethyl initiated a new test program to support a waiver request. Serious technical questions were raised by EPA as to the adequacy of both the 1978 and 1981 waiver efforts. With respect to the 1978 decision, for example, major questions were raised regarding the "representativeness" of the test fleet considered in the proceeding, and the comprehensiveness of the emissions analysis conducted by Ethyl.

(continued...)

3. The 1988-1990 Test Program

In consultation with EPA and the automotive industry, Ethyl designed a test protocol in 1987 to determine the effect of the Additive on exhaust emissions.[12/] Ethyl's test fleet represents approximately 53 percent of the automobiles sold in the United States in 1988.[13/] The 48 fleet automobiles generally represent the most popular engine configurations for that year and include automobiles manufactured by the three largest domestic manufacturers -- Chrysler, Ford and General Motors.

[11/] (...continued)
In the 1978 Waiver Decision, EPA concluded that Ethyl's test fleet was not "representative of the national in-use auto fleet." 1978 Waiver Decision at 7, n. 14; see also id. at 11, n. 24. EPA also concluded that Ethyl had not analyzed "all reasonably useable data sets. . . ." Id. at 8 (emphasis in original). The Agency therefore was forced to consider data from separate test programs which used different test protocols. See Characterization Report at 1. Moreover, the Agency itself acknowledged that much of the data it evaluated in 1978 were "developed under procedures which differed, often substantially, from those used in certification" of vehicles under section 206 of the Act. Id. at 5. Finally, as noted above, the lack of confirmatory data to support the theoretical argument presented to the Agency in 1981 to justify use of the Additive at 0.015625 gpg (a concentration not at issue in this proceeding) was fatal to Ethyl's waiver application in that year. For these reasons, the Agency concluded in both proceedings that Ethyl had not adequately demonstrated the effect of the Additive on emission control devices and systems.

With respect to the test program underlying this waiver application, Ethyl has consulted with EPA both during the design of the test program and in connection with the analysis of the test data to avoid the technical problems experienced in the prior waiver applications involving the HiTEC 3000 additive.

[12/] For a detailed description of the test protocol, see Appendix 1.

[13/] See Appendix 1, at Attachment 1-1. Included in the test fleet were vehicles using emission control systems likely to represent future emission control technology. See id. at 2.

The test program compared the exhaust emissions from paired sets of three vehicles fueled on clear fuel and the same base fuel containing the Additive, respectively, at mileage increments between 1000 miles and 50,000 miles (later extended to 75,000 miles). In accordance with the test protocol, drivers operated the test vehicles over a prescribed route representative of a range of typical driving conditions. As the vehicles accumulated mileage, Ethyl obtained exhaust emissions data for HC, CO, and NOx from each vehicle at 1000 miles, at 5000 miles, and at each 5000 mile increment thereafter.

The data were then analyzed to determine what, if any, effect the Additive had on exhaust emissions, as well as on other aspects of vehicle operation that might affect exhaust emissions. To make this determination, Ethyl applied the decision-making methodology used by EPA to evaluate Ethyl's 1978 waiver application. Ethyl also conducted additional statistical analyses to confirm the results generated by EPA's decision-making methodology. The results of the testing and statistical analyses, which are described in detail in Appendices 2A and 2B and summarized in the following sections, affirmatively demonstrate that the HiTEC 3000 additive does not cause or contribute to the failure of emission control devices and systems to meet applicable emission standards.

B. <u>Analysis of the 1988-90 Test Results</u>

The Agency has traditionally considered four major issues in waiver proceedings. These issues are the impact of the fuel additive on: (1) exhaust emissions; (2) evaporative emissions; (3) materials compatibility; and (4) driveability. A discussion of the criteria EPA applies to analyze exhaust emissions (the principal issue in this application), and the results of Ethyl's test program, follow. The other three issues (evaporative emissions, materials compatibility, and driveability) are discussed in the next section of this waiver application.

1. <u>EPA's traditional statistical tests</u>

The Agency's principal concern regarding the effect of the Additive on emission control devices has been its long-term, deteriorative effect on exhaust emissions.[14/] As reflected in the

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[14/] Exhaust emission data are analyzed according to the effects that a fuel is predicted to have on emissions over time. In EPA's words, "[i]f the fuel is predicted to have only an instantaneous effect on emissions, i.e., the emissions effect of the fuel remain constant throughout the useful life of the vehicle, then 'back-to-back' emission testing will suffice. . . If the fuel is predicted to have a long-term deteriorative effect[,] then 50,000 mile durability testing may be appropriate in addition." Conditional Grant of Application for a Fuel Waiver Submitted by Texas Methanol Corporation, EN-87-06 (February 1, 1988) (hereinafter "Texas Methanol Decision") at 9-10.

In its evaluation of Ethyl's 1978 waiver application, EPA determined that "MMT is expected to affect vehicle emissions over a period of time rather than 'instantaneously.' Therefore, conventional back-to-back emission tests of the same car on different fuels <u>would not be an appropriate test method to evaluate MMT effects</u>." Characterization Report at 15-16 (emphasis added). Notwithstanding this observation, Ethyl has conducted instantaneous testing to compare directly automobile emissions using a fuel containing the Additive and a clear fuel. The results of this testing confirm EPA's observation in the 1978 proceeding that the Additive does not have an instantaneous effect on exhaust emissions. <u>See</u> Appendix 2C. The discussion above therefore focuses on the potential long-term, deteriorative effect of the Additive on exhaust emissions.

Agency's prior waiver application decisions, there are two ways that a waiver applicant can demonstrate that a fuel does not cause or contribute to the failure of an emission control device or system to meet applicable emission standards over time. These two tests are referred to below as the "adverse effect" test and the "cause or contribute" test.

The adverse effects test -- First, an applicant can show that the fuel or fuel additive "does not have a statistically adverse emissions effect."[15/] That is, if an applicant can demonstrate that, when measured against a "clear fuel," the fuel additive does not generate emissions significantly in excess of those for clear fuel vehicles, the applicant has met the burden established by CAA § 211(f)(4).

In its evaluation of Ethyl's 1978 waiver application, EPA used seven statistical tests to examine whether the Additive would cause an adverse emissions effect.[16/] The results of these

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[15/] 1978 Waiver Decision at 8; see also Conditional Grant of Application for a Fuel Waiver Submitted by E.I. DuPont de Nemours and Company, Inc., EN-84-06, at 11 (January 10, 1985) (hereinafter "DuPont Decision") ("[I]t can be concluded that none of the gasoline-alcohol fuels showed adverse effects on exhaust emissions as a group, as compared to the base fuel. Therefore, I [the Administrator] conclude that this gasoline-alcohol fuel does not cause or contribute to the failure of vehicles to meet applicable emission standards.").

[16/] A detailed description of each test is presented in Appendix 2A. Briefly, the seven tests are: (1) deterioration factors; (2) least squares regression slopes; (3) maximum percent of vehicles failing standard; (4) mileage point at which the regression line first exceeds the standard; (5) change in emissions from low mile point to 50,000 miles; (6) change in emissions from low mile point to 5000 miles; and (7) integral

(continued...)

tests must be considered collectively to determine whether an adverse emission effect exists.[17/]

<u>The cause or contribute test</u> -- If this first series of tests shows a significant adverse emissions effect, then a final test is applied to address the impact of this change in exhaust emissions on compliance with applicable emission standards by the test fleet.[18/] This pivotal test evaluates whether the adverse emissions effect "causes or contributes" to a failure of the test fleet to meet applicable emission standards.

EPA has described the cause or contribute test somewhat differently depending upon whether the clear-fueled vehicles in the test program either meet or exceed the applicable emission standards. When all of the clear-fueled test vehicles meet the emission standards, EPA has described the "cause or contribute" test as follows:

16/ (...continued)
tailpipe emissions above the initial emissions level. An eighth test, comparison of initial emission levels, does not test for an adverse effect, but rather tests for a difference in initial emissions levels which might mask an adverse effect. <u>See</u> 1978 Waiver Decision at 16-18.

17/ In the 1978 Waiver Decision, EPA considered the results of <u>all</u> <u>seven</u> <u>tests</u> without relying on the results from any one test standing alone. <u>See</u> Characterization Report at 28. EPA analyzed the seven different characterizations of exhaust emissions because of "variations in protocols between test programs, uncertainty as to the nature of a possible MMT effect, uncertainty as to the effect of initial emission levels, and vehicle-to-vehicle differences. . . ." Characterization Report at 1.

18/ Conversely, if application of the first seven tests shows no adverse emissions effect, then no further analysis is required.

> In order to determine if the demonstrated adverse effect will cause or contribute to failure of vehicles to meet their HC emission standards at any time during their useful lives, we estimate[] the percent failure for each vehicle group and fuel and compare[] the results of each MMT-fueled vehicle group to its matching clear-fueled vehicle group . . . . In order to provide a frame of reference against which to analyze our data, we treat[] a failure as occurring when more than 10% of a class of vehicles fail[] to meet their designed emissions standards at any point in their useful lives . . . In the case where a clear-fueled vehicle class does not, at a particular mileage point, exceed the 10% failure rate, MMT would cause failure if, at the same mileage point, the matching MMT-fueled vehicle class exceeds the 10% failure rate.[19/]

EPA has described the test in somewhat different terms when both clear-fueled and additive-fueled vehicles exceed the applicable emission standard:

> [I]n the case where a clear-fueled vehicle class exceed[s] the 10% failure rate, at a particular mileage point, MMT would be contributing to failure of that class if, at the same mileage point, it was found that the matching MMT-fueled vehicle class exceed[s] the percent failure of the clear-fueled vehicle class or exceed[s] the 10% failure rate at an earlier mileage point than the clear-fueled vehicle class.[20/]

Under the cause or contribute test, once EPA computes the number of "failure" observations applying the 10 percent criterion to each vehicle class, EPA then determines whether the number of failure observations, taken as a whole, is

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19/ 1978 Waiver Decision at 21 (emphasis added).

20/ Id. at 21-22.

statistically significant. A fuel additive fails the cause or contribute test only if the number of vehicle groups failing the test is statistically significant.[21]

2. Application of the traditional statistical tests to the 1988-90 test results show that the Additive will not cause or contribute to the failure of emission control devices or systems.

Ethyl retained an independent consultant, Systems Applications, Inc. ("SAI"), to analyze Ethyl's 1988-90 fleet data using EPA's tests from the 1978 Waiver Decision. Application of these statistical tests to the data from the first 50,000 miles of vehicle operation establishes that the Additive does not cause or contribute to the failure of emission control devices or systems to meet applicable emission standards for NOx, CO, or HC. Moreover, application of these tests show that the Additive has an overall beneficial effect on exhaust emissions, and that this beneficial effect increases from 50,000 to 75,000 miles.[22]

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[21] See Characterization Report at 21. The Agency determines statistical significance by comparing the number of vehicle groups that fail the test to the number of vehicle groups that pass the test using standard statistical procedures. If a sufficient number of vehicle groups pass the test, the fuel additive passes the test.

[22] While only the 50,000 mile data set is strictly relevant to this waiver application under the statutory standard, see 42 U.S.C. § 7545(f)(4), Ethyl has also applied the traditional EPA statistical tests to the 75,000 mile data set given the possibility that amendments to the Clean Air Act could extend the certification period beyond 50,000 miles for future model year vehicles.

a. NOx emissions

Both the 50,000 and 75,000 mile data sets for NOx emissions pass each of the seven statistical tests used to determine whether the additive has an adverse emissions effect.[23/] Indeed, the data convincingly demonstrate that use of the Additive has a beneficial impact on NOx emissions, which are reduced on average, 0.07 gpm for the first 50,000 miles, and 0.11 gpm for the full 75,000 miles.[24/] This translates into an annual reduction of automotive NOx emissions of potentially over 633 million pounds by 1999.[25/] Standing alone, this finding satisfies the burden

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23/ See Appendix 2A, at 70.

24/ These numbers are based on data set "Ethyl4S2," one of four data sets used by SAI to analyze the Additive's effect on emissions. A detailed description of the four data sets is provided in Appendix 2A. The data set Ethyl4S2 is the data set that presents the most conservative assessment of the effect of the Additive on exhaust emissions -- i.e., it results in the smallest estimate of net pollutant reductions. See Appendix 7.

The other data sets were designed to examine the effects of "tester" and emission control component change effects. None of the other data sets, however, result in very different emission estimates. For example, using the data set which reflects the effect of component changes after 50,000 miles of vehicle operation, data set Ethyl4S3, the average effect of using the Additive for the first 50,000 miles of operation remains a reduction in NOx emissions of 0.07 gpm, but improves to an average decrease of 0.12 gpm over the full 75,000 miles of operation.

25/ See Appendix 7, at 4. These results are fully consistent with EPA's determination in connection with Ethyl's 1978 waiver application that "NOx failed to show an adverse effect." See Characterization Report at 2.

established under CAA § 211(f)(4) with respect to NOx emissions.[26/]

b. CO emissions

Like NOx, both the 50,000 and 75,000 mile CO data sets pass each of the seven statistical tests used to determine whether the Additive has an adverse emissions effect.[27/] As with NOx, the statistical tests demonstrate that the Additive has a beneficial impact on CO emissions, reducing CO emissions, on average, 0.09 gpm for the first 50,000 miles, and 0.22 gpm for the full 75,000 miles.[28/] The Additive therefore will contribute to an annual reduction in CO automotive source emissions of potentially over 985 million pounds by 1999.[29/] As with NOx, this finding satisfies the burden established under CAA § 211(f)(4) for CO exhaust emissions.[30/]

26/ See 1978 Waiver Decision at 8; DuPont Decision at 11. Although unnecessary to meet the burden under § 211(f)(4), SAI also analyzed the NOx data using the cause or contribute test. Not surprisingly, both the 50,000 mile and 75,000 mile NOx data sets pass this test as well. See Appendix 2A, at 54 and 66.

27/ See Appendix 2A, at 70. This result therefore confirms EPA's determination in 1978 that the Additive does not adversely effect CO emissions. See Characterization Report at 2.

28/ Using data set Ethyl4S3, the data set which corrects for the effects of emission control component changes completed in the vehicles at 50,000, CO emissions drop on average 0.09 gpm for the first 50,000 miles of operation using the Additive, and 0.34 gpm for the full 75,000 miles of operation. See Appendix 2A, at D-33.

29/ See Appendix 7, at 4.

30/ SAI also analyzed the CO data set using the cause or contribute test. For both the 50,000 mile and 75,000 mile data (continued...)

c. HC emissions

The adverse effects test -- The 50,000 mile data set for HC emissions shows no adverse effect for six of the seven adverse effects measured by EPA's adverse effects test. The one test that suggests an emissions effect is the test for the "change in emissions from low mileage point to 5000 miles."[31] SAI calculated that HC emissions from 1000 miles (1K) to 5000 miles (5K) were 0.017 gpm greater in the test cars using the Additive, an increase which SAI determined to be statistically significant.[32] Of note, however, this increase is exactly the same as the increase reflected for the HiTEC 3000 additive in the "integrated emissions above initial levels test," a result which suggests that any short-term (1K to 5K) deterioration in HC emissions for cars using the Additive does not increase in the long-term (5K to 50K).

Indeed, this is exactly the conclusion that SAI reaches based on the results of applying the "integrated emissions above

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30/ (...continued) sets, the CO emissions data also pass this test. See Appendix 2A, at 54 and 66.

31/ See Appendix 2A, at 41. While the "integral tailpipe emissions above initial tailpipe emission levels" test shows some effect, this effect disappears if the test is run using only 5000 mile through 50,000 mile data. Id. at 43. This means that the effect indicated by this test depends solely upon the change in emissions from the 1000 mile to the 5000 mile points, which is the same effect indicated by the "change in emissions from low mileage point to 5000 miles" test. Thus, as a practical matter, the "change in emissions from low mileage point to 5000 miles" test is the only test which actually shows an HC effect.

32/ Id. at 39-41.

initial levels test" using the 5000 mile emission results as the starting point.[33] From 5000 miles to 50,000 miles, therefore, there is no statistically significant difference in the integrated emissions, measured from the emission levels at the 5000 mile test interval, for the two test fuels.[34] This implies that any difference in HC emissions between the two test fuels is solely attributable to the very small change in emissions which occurs from the 1000 mile to 5000 mile intervals.[35]

Of particular importance with respect to an evaluation of this short-term HC emissions effect, the Additive passes the deterioration factor test. This test is arguably the most important of the seven adverse effect tests because of its similarity to the EPA test used to certify that automobiles are in compliance with emission standards.[36] The deterioration factor test shows that the weighted-average (by vehicle sales) deterioration factor for the group of test vehicles using the Additive was less than that for the group of clear-fuel test

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[33] Id. at 44, Table 4-7.

[34] If the same test is run on the 75,000 mile data set, the results show that there is no statistically significant difference in the integrated emissions from the cars in the test fleet operating on clear-fuel and those operating on the HiTEC 3000 additive from the 5000 mile reference point to 75,000 miles. Id. at 58.

[35] Id. at 44.

[36] See, e.g., 40 C.F.R. § 86.088-28(a)(4)(i)(B). The deterioration factor is a measure of the predicted change in emissions of a regulated pollutant from 4000 miles to 50,000 miles for a particular vehicle. Id.

vehicles. Because the deterioration factor is calculated by fitting the "best fit" regression line to all of the data points -- both short-term and long-term -- this result further implies that the initial short-term HC emissions effect (1K to 5K) does not increase in the long-term (5K to 50K).

Moreover, that the Additive shows no adverse effect for six of the seven adverse effects measured by EPA is not surprising in light of the very small impact on HC emissions reflected in the test data. SAI calculated that the Additive increased HC emissions in the test program on average only about 0.018 gpm during the first 50,000 miles. Such a small HC emissions increase, even if reflected in the certification testing conducted on the prototype vehicles of each of the models used in the test fleet,[37] would have absolutely no adverse effect on the certification results for each model.[38] That is, the prototype vehicles for each of the car models used in the test program would have been certified to be in compliance with the HC emission standard even if they were operated on fuel containing the Additive.

Finally, the test data suggest that the very small HC emission effect observed in the vehicles using the Additive for

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[37] Section 206 of the CAA requires EPA to test new motor vehicles and engines to certify compliance with emission standards for mobile sources established under section 202 of the Act. See 42 U.S.C. § 7525.

[38] See Appendix 2A at 48-49.

the first 50,000 miles of operation may, in fact, diminish between 50,000 and 75,000 miles.[39/] Mean integrated emissions for the full 75,000 miles of vehicle operation range from no higher than 0.018 gpm to as low as 0.010 gpm, depending upon how the test data are interpreted.[40/]

For these reasons, this slight HC emissions effect cannot be deemed to be material to a decision on this waiver application. Application of EPA's adverse effect tests, and of modifications to those tests, demonstrates that the Additive does not have a long-term deteriorative effect on HC emissions. While the test results show that use of the Additive causes a statistically detectable increase in emissions in the short-term (1K to 5K), this short-term effect, as discussed more fully below, has no practical impact on the test fleet's capability of meeting the HC emission standard.

The cause or contribute test -- The acceptability of the Additive with respect to HC emissions is further confirmed by the results of the pivotal cause or contribute test from the 1978 Waiver Decision. This is the test used to determine whether the additive causes or contributes to the failure of the test fleet to meet applicable emission standards over the course of the 50,000 mile durability test cycle.[41/] Application of this test to

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39/ See id. at 61, Table 4-16.

40/ See id. at 60-61.

41/ See supra pp. 13-15.

the 50,000 mile data set shows that the Additive will not cause or contribute to the failure of emission control devices or systems to meet the HC emission standard.[42]

That the Additive does not cause or contribute to the failure of emission control devices is fully consistent with the results of Ethyl's test program. The test data show that whenever the HC emission standard was exceeded by a vehicle model, the HC exceedance occurred for both the clear and the Additive-fueled vehicles in that model group. That these HC exceedances occurred in a uniform fashion, independent of the fuel type involved, demonstrates that the Additive is not the reason those vehicles exceeded the HC emission standard. This conclusion is confirmed by application of statistical tests which show that, when vehicles exceeded the standard, the vehicles fueled with the Additive did not, from a statistical standpoint, exceed the HC standard any earlier than the clear-fueled vehicles.[43]

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[42] See Appendix 2A, at 55. The same result is shown when the cause or contribute test is applied to the 75,000 mile data set. Id. at 66.

It should be noted that since all of the test vehicles have three-way catalyst emission control systems, one need only consider the statistical results associated with a single grouping made up of all eight vehicle groups. By contrast, in the 1978 Waiver Decision, EPA had to examine three groupings -- oxidation catalysts (0.41 HC standard), three-way catalysts (0.41 HC standard), and oxidation catalysts (1.5 HC standard) -- for purposes of determining statistical significance. See Characterization Report at 27.

[43] See Appendix 2B, at 30.

The overall impact of the Additive on HC emissions in the test program is also consistent with the conclusion that the Additive does not cause or contribute to the failure of emission control systems. On average, HC emissions for the vehicles using the Additive in Ethyl's test fleet were 0.28 gpm for the first 50,000 miles, and 0.31 gpm for the full 75,000 miles.[44] This represents an emission level that is, on average, 24 to 31 percent below the HC emission standard.

Finally, the very small HC increase associated with the Additive in the test program does not take into account the octane boosting property of the Additive, a property which will allow refineries to reformulate unleaded gasoline by reducing the aromatic content of the fuel.[45] Once aromatics used to achieve required octane levels are reduced and replaced by the Additive, tailpipe emissions of various pollutants, including HC, will be reduced.[46] This will tend to eliminate in commercial operation even the unimportant HC effect observed in the Ethyl test program.

In summary, application of the statistical tests used by EPA to evaluate Ethyl's 1978 waiver application, together with

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[44] See Appendix 2A, at D-25.

[45] See Appendix 6, at 3; infra pp. 46-49. Modifying the aromatic content of a fuel is one means of changing octane.

[46] For a more detailed discussion of the effect of reducing the aromatic content of gasoline on tailpipe emissions, see infra pp. 46-49.

modifications to those tests, demonstrates that the HiTEC 3000 additive does not have a material adverse impact on HC exhaust emissions, and does not cause or contribute to the failure of emission control devices or systems to meet the HC emission standard.

3. Additional statistical analyses confirm that the HiTEC 3000 additive will not cause or contribute to the failure of emission control devices or systems.

In order to perform a thorough statistical analysis of the test data, Ethyl selected a second statistical consultant to perform an independent analysis of the data. Ethyl asked Roberson Pitts, Inc. ("RPI") to determine the most useful (and most severe) statistical techniques for analyzing the test data, and to determine whether the Additive would cause or contribute to the failure of emission control devices or systems to meet applicable emission standards.

In response to this request, RPI performed three types of analyses. First, RPI conducted a t-test for each vehicle group at each mileage interval to assess the effect of fuel type (the HiTEC 3000 additive versus clear) on exhaust emissions.[47]

[47] A t-test is used to determine if the difference between two sample means can be attributed to something other than normal sampling variability. A t-test is derived by taking the difference between two sample means and dividing it by a quantity called a "standard error." A standard error measures the variability expected to be seen between two sample means when repeated samples are drawn from a given population. The quotient (i.e., the difference in means divided by the standard error) is called the "t-ratio," and is a measure of how many standard errors away from zero the difference in means is. Statistical (continued...)

Second, RPI pooled the test data by mileage interval (e.g., at 20,000 miles, there were 47 test vehicles which yielded 47 NOx measurements, 47 CO measurements, and 47 HC measurements), and applied a statistical model to these data to obtain an overall comparison of emissions for the respective test fuels by mileage interval (hereinafter the "pooling test").[48/] Using the pooling analysis, RPI was also able to predict which, if any, vehicle models exceeded applicable emission standards at the various mileage intervals.[49/]

Third, RPI determined that a quadratic model provided the best fit for the test data and applied that model to analyze trends in vehicle emissions, including the mileage points at which cars first exceeded emission standards for each pollutant.

[47/] (...continued)
theory is then used to compute the probability of a t-ratio exceeding any given value when sampling from two normal populations that actually do not differ in means. Traditionally, a t-ratio that has less than a 5 percent chance of being observed under the "equal population means" assumption is taken as statistically sufficient evidence that there is a difference in the means of the two populations.

[48/] Although there were 48 test vehicles included in the test program, RPI used data from only 47 vehicles because one of the test vehicles was involved in a serious accident after about 7500 miles of operation. See Appendix 2B, at pp. 2 & 14; Appendix 1, at Attachment 1-15, Table 2 (Car D-3). In its analysis, RPI indicated that the pooling analysis is fairly simplistic because, unlike the quadratic analysis discussed below, it does not allow examination of car-model specific fuel effects. See Appendix 2B, at 15.

[49/] These predictions are based on adjustments to the fleet average depending upon car model and fuel-type emission effects. Id. at 14.

RPI also used the quadratic models to determine average emissions and differences in average emissions between clear-fuel cars and cars using fuel containing the Additive.

RPI applied these statistical tests to both the 50,000 mile and 75,000 mile data sets. These analyses are summarized below, and discussed in detail in Appendix 2B.

a. NOx emissions

Applying the t-test analysis to the 50,000 mile data set, there are 22 out of 88 t-tests where clear fuel vehicles had statistically higher NOx emissions than vehicles using the Additive, and three cases where vehicles using the Additive had statistically higher emissions than clear fuel vehicles. If there were no fuel effect on emissions, sampling variability would lead the analyst to expect about five cases (0.05 x 88 = 4.4) in each category.[50/] Thus, the effect of the Additive on NOx emissions is shown to be beneficial.[51/]

The pooling test described above shows that, from 30,000 miles and beyond, clear fuel results in statistically higher NOx emissions than does the fuel containing the Additive.[52/] The

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50/ See Appendix 2B, at 10.

51/ The results of an analysis of the 75,000 mile data set show that the Additive's beneficial effect on NOx emissions increases with increasing mileage. For the 75,000 mile data set, there remain three cases where vehicles using the Additive had statistically higher NOx emissions, but 41 cases where the Additive results in statistically lower NOx emissions than clear fuel. Id. at 39.

52/ See id. at 18.

pooling test also shows that the magnitude of the estimated difference in NOx emissions increases with increasing mileage. Indeed, the only vehicles predicted to exceed the NOx standard during the first 50,000 miles of operation are the clear fuel vehicles for one of the test models.[53/] The advantage of the Additive fuel over clear fuel continues to grow in magnitude to at least 75,000 miles.[54/]

Finally, using the quadratic analysis, RPI concludes that switching from clear fuel to the fuel containing the Additive decreases average NOx emissions by 0.059 gpm for the first 50,000 miles.[55/] This advantage of the Additive grows to 0.097 gpm for the full 75,000 miles. These results confirm the results of the traditional EPA statistical tests: the HiTEC 3000 additive does not cause or contribute to the failure to achieve the NOx emission standard. To the contrary, use of the Additive has a substantial beneficial impact on NOx exhaust emissions.

53/ See id.

54/ See id. at 42.

55/ Id. at 6. RPI's analysis of the pollutant emissions differs from SAI's analysis in that RPI based its analysis solely on the data set Ethyl4S2, without "weighting" the emission results as a function of 1988 vehicle sales figures or "scaling" the emission results to reflect any initial emission differences in the test vehicles at the 1000 mile test interval. See id., at 2; cf. Appendix 2A, at 31 and 44-45. For this reason, RPI's average emission numbers for NOx, CO, and HC are slightly different from SAI's numbers. Also, because none of the vehicles using the Additive exceeded the NOx standard, RPI did not conduct an analysis of the exceedance mileage points.

b. CO emissions

The t-test demonstrates that, with respect to the 50,000 mile data set, there are 12 cases where clear fuel vehicles had statistically higher CO emissions than vehicles using fuel containing the Additive, but only eight cases in which vehicles using the Additive had statistically higher emissions.[56] If there were no fuel effect on emissions, the analyst would expect to see about five cases in each of these categories based on normal sampling variability. These numbers suggest that fuel containing the Additive is no more likely to lead to higher CO emissions than clear fuel and, given the greater number of cases where the clear fuel vehicles had greater CO emissions, may reduce CO emissions.[57]

The pooling test confirms the conclusions generated by the t-tests. It shows no effect of the Additive on CO emissions at early mileage points. At later mileage points (i.e., the 45,000 mileage point and beyond), the clear fuel vehicles generated statistically higher CO emissions than the vehicles using fuel

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56/ See id. at 10.

57/ These results improve in favor of the Additive when this analysis is applied to the 75,000 mile data set. Using the 75,000 mile data set, there are 21 cases where clear-fuel cars have statistically higher CO emissions than cars containing the Additive, and only nine cases where the Additive results in statistically higher CO emissions. Id. at 35. These results suggest that the Additive has a beneficial impact on CO emissions.

containing the Additive.[58] Moreover, the pooling analysis predicts that more clear-fuel vehicle models will exceed the CO emission standard than vehicle models using the Additive.[59] This advantage in favor of the Additive continues to grow in magnitude all the way to 75,000 miles.[60]

Finally, the quadratic analysis shows that, over the full 50,000 mile test range, CO emissions are slightly lower (0.003 gpm on average) for vehicles using the Additive.[61] This reduction in CO emissions improves to 0.139 gpm for the full 75,000 miles of vehicle operation.[62] And, with respect to vehicles that exceed the CO standard, the quadratic analysis shows that there is "<u>no</u> difference between clear fuel and HiTEC 3000" for the fleet in terms of when the CO standard exceedances occur.[63] Thus, the Additive does not cause or contribute to the failure of vehicles to meet the CO emission standard.

c. <u>HC emissions</u>

For the first 50,000 miles of vehicle operation, RPI's statistical analysis indicates that the vehicles using the Additive had slightly higher HC emissions than the clear fuel

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[58] <u>See</u> <u>id.</u> at 17.

[59] <u>See</u> <u>id</u>. at 18.

[60] <u>See</u> <u>id</u>. at 41.

[61] <u>Id</u>. at 26.

[62] <u>Id</u>. at 50.

[63] Appendix 2B, at 34 (emphasis added).

vehicles (about 0.023 gpm, on average).[64/] This difference decreased to 0.020 gpm on average over the full 75,000 miles of vehicle operation. Not only is this emissions difference extremely small but, as explained more fully below, the HC emissions difference does not have a practical effect on compliance with the HC emission standard.[65/]

The pooling test establishes that vehicles fueled with the HiTEC 3000 additive were no more likely than their clear fuel counterparts to exceed the HC emission standard at some point within either the 50,000 mile or 75,000 mile test range.[66/] Application of the pooling test also demonstrates that:

> * There was no real difference in HC emissions between the two fleets of vehicles when the Additive fuel versus clear fuel tests began (i.e., at the 1,000 mile interval). At 25,000 miles, HC emissions from the two sets of test vehicles were also statistically indistinguishable.
>
> * Although HC emissions from vehicles using the Additive initially increased faster than from those vehicles using clear fuel, this trend changed so that from 45,000 miles to the end of the 75,000 mile test program, there was no statistically significant difference in HC emissions between the two fleets of vehicles.

64/ Id. at 6. As noted, RPI's emission numbers are slightly different from SAI's numbers as a result of a slightly different analytical approach. See supra note 55.

65/ See infra p. 31.

66/ See Appendix 2B, at 40-41.

Finally, the quadratic analysis shows that, for the three vehicle models predicted to exceed the HC standard, the exceedance mileages for the clear fuel and the Additive fueled vehicles were statistically indistinguishable.[67/] This means that the vehicles fueled with gasoline containing the Additive were no more likely to exceed the HC standard at a given mileage point within the 50,000 mile test range than the clear fuel vehicles. RPI therefore concludes that the HiTEC 3000 additive does not cause or contribute to the failure of emission control devices or systems to meet the HC emission standard.[68/]

C. The HiTEC 3000 Additive Will Not Have An Adverse Impact On Evaporative Emissions, Materials Compatibility, and Driveability.

As noted above, EPA has considered several factors in addition to exhaust emissions when evaluating waiver applications under § 211(f) of the Act.[69/] These factors include the effect of a fuel or fuel additive on: (1) compliance with evaporative emission standards, (2) the materials used in a vehicle's fuel and emission systems, and (3) a vehicle's driveability. As described more fully below, Ethyl has conducted additional test programs that demonstrate that the Additive does not adversely affect any of these other parameters.

67/ See Appendix 2B, at 30.

68/ See id.

69/ See supra pp. 10-11.

1. Evaporative emissions

The Additive does not adversely affect a vehicle's ability to meet evaporative emission standards.[70] Several hundred billion vehicle miles have been accumulated in Canada on vehicles using the HiTEC 3000 additive without any reported compliance problems relating to evaporative emission standards.

Because the Additive has a vapor pressure of 0.05 mm mercury at 20 degrees Celsius ("C"), with a boiling point of 232 C, addition of the Additive to unleaded gasoline at a concentration up to 0.0024 volume percent (0.03125 grams manganese per gallon) will have no effect on evaporative emissions.[71] Nevertheless, to confirm this conclusion empirically, Ethyl used the 1978 SHED test procedure to measure the evaporative emissions on eight of the test fleet vehicles after 50,000 miles. Four of the vehicles used clear fuel and four used clear fuel plus the HiTEC 3000 additive.

The evaporative emission test results, which are provided in Appendix 3, confirm that the Additive has no effect on

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70/ With respect to evaporative emissions, the applicant must show that use of the fuel additive "would not cause or contribute to a failure of any emission control device or system to achieve compliance by the vehicle with the evaporative emission standards. . . ." Texas Methanol Decision, at 16.

71/ During the test protocol planning phase, EPA acknowledged that the Additive was not likely to affect evaporative emissions, and agreed that evaporative emissions testing at 5000 mile intervals was not necessary. See Appendix 1, at 5.

evaporative emissions.[72] All evaporative emission measurements from vehicles using the Additive remained well below the evaporative emission standard, and were comparable, on average, to the emission measurements from the corresponding clear fuel vehicles.

2. Materials compatibility

Use of the Additive does not adversely affect materials used in vehicle fuel or emission systems.[73] As in the case of compliance with evaporative emission standards, billions of miles of vehicle service have been accumulated in Canada on unleaded gasoline containing the Additive without any confirmed reports of fuel system or emission system failures attributable to the HiTEC 3000 additive.

Automotive materials -- To confirm more directly the Canadian experience, Ethyl retained Cortest Engineering Services to test the compatibility of gasolines containing the Additive with vehicle metals and non-metals using various standard compatibility tests.[74] For the metals, the Additive did not significantly affect any of the relevant short or long-term test

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72/ *See* Appendix 3, at 14.

73/ With respect to materials compatibility, the Agency has examined whether a fuel or fuel additive would cause changes in carburetor or fuel system components that impair the performance of the vehicle and that adversely affect emissions. *See*, *e.g.*, Texas Methanol Decision, at 11.

74/ For a more detailed description of the compatibility testing, *see* Appendix 3, at 7-12.

parameters, including percentage of the surface area that rusted in the presence of the Additive, weight change per unit area, and appearance. For the elastomers and plastics, the Additive did not significantly affect tensile strength, hardness, elongation at break, or change in weight or volume. The results of the compatibility testing demonstrate that the Additive in unleaded gasoline will not adversely affect fuel system components.[75]

High Speed Testing -- Ethyl conducted several additional test programs to examine the effect of the Additive on the durability of emission control systems, and to determine whether use of the Additive would cause plugging of the catalytic converter. The first program involved high-speed mileage accumulation on a set of 1989 Ford Crown Victorias. The test protocol required the two vehicles, one operating on clear fuel and the second with a fuel containing the Additive, to follow a driving cycle with a maximum speed of 65 mph for about 45 percent of the mileage during the first 25,000 miles, and at 80 mph for about 45 percent of the mileage during an additional 10,000 miles.

Following completion of the 25,000 mile portion of the mileage accumulation, and again after completion of an additional 10,000 miles, Ethyl tested the exhaust back pressure for each vehicle. The exhaust back pressure is a measure of the total pressure ahead of the catalyst. The exhaust back pressures for

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[75] See id. at 9-12.

the vehicles using the Additive remained the <u>same</u> as those for the clear-fueled vehicles.[76] This indicates the Additive was not plugging the catalyst.

<u>Catalytic Conversion Efficiencies</u> -- Ethyl also evaluated the conversion efficiency of the emission control systems of the 48 vehicles in Ethyl's durability test fleet after the accumulation of 1000 miles, 50,000 miles and 75,000 miles.[77] The conversion efficiency is a measure of the degree to which the catalytic converters reduce the emission of regulated pollutants. To calculate the conversion efficiency of the catalytic converters on vehicles used in Ethyl's test fleet, Ethyl measured vehicle emissions for the models in the test fleet before they entered the catalyst and again as they were emitted from the tailpipe at three different mileage intervals: 1000 miles, 50,000 miles, and 75,000 miles.

The results of this testing show that the HiTEC 3000 additive had no adverse effect on the conversion efficiency of emission control systems, and actually increased catalyst efficiencies for HC and NOx emissions, while maintaining an equivalent conversion efficiency for CO.[78]

<u>Exhaust Back Pressures for the Test Fleet</u> -- Ethyl also measured the exhaust back pressures for the vehicles in the 48

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[76] <u>See id.</u> at 6.

[77] <u>Id</u>. at 3.

[78] <u>See id.</u> at 4.

car test fleet after the completion of 75,000 miles of operation. A comparison of the back pressure measurements for the clear fuel vehicles and the vehicles fueled with the HiTEC 3000 additive shows that the Additive does not adversely affect catalyst back pressures.[79]

100,000 Mile Tests -- To test the extended durability of engine and emission system components, Ethyl operated four 1988 Chevrolet Corsicas equipped with 2.0 liter engines and three-way catalytic converters for 100,000 miles. Two of the vehicles were operated on Howell EEE fuel, and two vehicles were operated on the same fuel plus the Additive at a concentration of 0.03125 grams manganese per gallon. Test mileage was accumulated on a route of streets and roads chosen in accordance with EPA Federal Test Procedures for emission system durability. Following completion of 100,000 miles of operation, Ethyl conducted testing to compare the conversion efficiencies and the catalytic converter exhaust back pressures for the two sets of vehicles.

The results of these comparisons demonstrate that the HiTEC 3000 additive does not adversely affect the operation of engines and emission systems. Catalytic converter performance in the two cars operating on fuel with the Additive was the same, or better than, that for the two cars operating on clear fuel after 100,000 miles of vehicle operation. The vehicles operating on fuel containing the Additive exhibited slightly better HC conversion,

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[79] See id. at 5.

equal CO conversion, and dramatically improved NOx conversion efficiency.[80/] Moreover, the two sets of vehicles had equivalent exhaust back pressures.[81/] These test results show that, even if Congress extends the useful life of emission control systems to 100,000 miles, use of the Additive will not cause plugging in the catalyst or otherwise adversely affect the durability of these systems.

Oxygen Sensors -- Finally, Ethyl evaluated whether the use of the Additive would adversely affect the durability of oxygen sensors.[82/] Adhering to a strict test protocol,[83/] Ethyl directly compared the performance of the oxygen sensors used in the clear and HiTEC 3000-fueled vehicles in the 48 car test fleet following 50,000 miles of vehicle operation. This comparison showed no statistically significant difference in the performance of the oxygen sensors in the clear versus HiTEC 3000-fueled vehicles.[84/]

Collectively, the foregoing test results show that the HiTEC 3000 additive will not cause catalyst plugging or otherwise adversely affect the durability of emission control systems.

80/ See Appendix 3, at 6.

81/ Id. at 7.

82/ See id. at 2. Oxygen sensors are located in the exhaust system to control the fuel flow in order to provide the correct air/fuel ratio to the engine. Improper operation of the oxygen sensor can lead to excessive exhaust emissions and/or faulty engine performance.

83/ See id. at 2.

84/ See id. at Attachments 3-2 through 3-9.

3. Driveability[85/]

The Additive will not affect driveability because, at a concentration of 0.03125 grams manganese/gallon, it does not change the volatility, density or handling characteristics of unleaded gasoline.[86/] To confirm that the Additive does not adversely affect driveability, Ethyl, during the course of the 48 car durability testing, required drivers to report on the "driveability" of the vehicles fueled with clear fuel and fuel containing the Additive. The test protocol required the drivers of the test vehicles to maintain a log describing the occurrence of any unusual circumstances relating to driveability, such as poor starting and stalling.[87/] The vehicle logs for the vehicles using the HiTEC 3000 additive show no evidence of any driveability problems attributable to the Additive. Together with the foregoing studies that show that the Additive will not adversely affect automotive parts or systems, the test program confirms that the Additive does not adversely affect vehicle driveability.

[85/] The Agency has observed that "poor driveability can directly result in increased emissions due to constant misfires and repeated stalling, and possibly lead to tampering with the emission controls of the vehicles." 46 Fed. Reg. at 48977. The Agency therefore considers vehicle driveability in evaluating CAA § 211(f)(4) waiver applications.

[86/] See Appendix 3, at 15.

[87/] See id. at Attachments 3-21 and 3-22.

III. THE AGENCY'S PRIOR INTERPRETATION AND APPLICATION OF THE § 211(f)(4) WAIVER STANDARD CONFIRMS THAT THIS APPLICATION SHOULD BE GRANTED.

A. The Statutory Standard

When Congress enacted amendments to the Clean Air Act in 1970, it required EPA to establish a program for registration and testing of fuels in order to ensure that fuels and fuel additives would not adversely affect the operation of pollution control devices in automobiles.[88] During the early 1970s, however, EPA experienced difficulty in developing a program for the large number of potential automotive fuels and fuel additives.[89]

In 1977, therefore, Congress amended the Clean Air Act to create what it believed would be a more workable program for regulating automobile fuels and fuel additives.[90] Under § 211(f) of the Act as amended, Congress required manufacturers of new fuels and fuel additives to demonstrate that their products would not adversely affect the capability of emission control devices

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88/ See 42 U.S.C. § 7545(c).

89/ See The Envtl. Policy Div. of the Congressional Research Ser. of the Library of Congress, A Legislative History of the Clean Air Act Amendments of 1977, (Comm. Print, Senate Comm. on Env't and Public works 1978) (Serial No. 95-16) (hereinafter "1977 Legis. Hist.") at 1464-1465 ("It was the Committee's view that emission systems currently in use could not be adequately protected from possible deterioration by these provisions of existing law [requiring registration and testing of fuels and fuel additives] due to the delay associated with statutory procedural safeguards of the subsection.").

90/ See Pub. L. No. 95-95, 91 Stat. 685 (1977). For ease of reference, the 1977 amendments to the Clean Air Act shall be referred to as the "1977 Amendments."

in automobiles to meet applicable emission standards. Congress achieved this result by prohibiting the "general use" of new fuels and fuel additives until the manufacturer demonstrates to EPA that the fuel or fuel additive "will not cause or contribute to a failure of any emission control device or system" to meet the emission standards for which the vehicle has been certified under the Act.[91/]

This "cause or contribute" standard applies only to the effect of the fuel additive "over the <u>useful life</u> of any vehicle in which [the emission control] device or system is used."[92/] The Act defines the "useful life" of a vehicle as "a period of use of five years or of fifty thousand miles (or the equivalent), whichever first occurs."[93/] For this reason, a waiver applicant must generally address the effect, if any, of a fuel additive on emission control systems over 50,000 miles of operation, and in vehicles which are five years old or less. Today, this means that testing must be conducted on vehicles using three-way type catalyst technology.[94/]

91/ 42 U.S.C. § 7545(f)(4).

92/ <u>Id</u>. at § 7545(f)(4).

93/ <u>Id</u>. at § 7521(d)(1).

94/ Because all of the vehicles to which emission standards currently apply in the United States use three-way catalyst technology, Ethyl structured its test program to focus on these vehicles. <u>See</u> Appendix 1, at Attachment 1-1. The effect, if any, of the Additive on older vehicles using oxidation technology, or no catalyst technology at all, is not legally relevant to this waiver application.

By enacting § 211(f), Congress did not intend to prevent, nor to allow the Agency to prevent, the introduction into commerce of "more efficient, less costly, and less polluting substitutes for conventional fuels."[95] Rather, as stated in the Conference Report for the 1977 Amendments, Congress enacted § 211(f) "to prevent the untested use of additives with cavalier disregard for harmful effects on emission control systems and devices."[96]

As explained by Congress:

> The waiver process . . . was established . . . so that the prohibition could be waived, or conditionally waived, rapidly if the manufacturer of the additive or the fuel establishes to the satisfaction of the Administrator that the additive, whether in certain amounts or under certain conditions, will not be harmful to the performance of emission control devices or systems.[97]

Moreover, reflecting Congress' belief that the development of fuels and fuel additives could further the air quality goals of the Act, Congress expressly required the Agency to "give special emphasis" to the research and development of fuels or fuel additives "which, when used, result in decreased atmospheric emissions."[98] Consistent with this legislative history, § 211(f)

95/ American Methyl Corp. v. United States Environmental Protection Agency, 749 F.2d 826, 839-840 (D.C. Cir. 1984).

96/ 1977 Legis. Hist. at 362 (emphasis added).

97/ 1977 Legis. Hist. at 1465 (emphasis added).

98/ 42 U.S.C. § 7404(a)(1)(E) (emphasis added).

should be applied to encourage the development and use of promising fuels and fuel additives.

B. The Agency's Application of the Statutory Standard

The Agency's prior interpretation and application of the cause or contribute standard under § 211(f)(4) has been consistent with Congress' intent that the Agency encourage the development and use of promising fuels and fuel additives. The Agency's adherence to these congressional goals is reflected in the waiver application decisions issued in the period since enactment of the 1977 Amendments.[99/]

[99/] The Agency has granted or conditionally granted waiver application decisions in the following cases: 53 Fed. Reg. 33846 (September 1, 1988) (15% MTBE); 53 Fed. Reg. 3636 (February 8, 1988) (Octamix); 50 Fed. Reg. 2615 (January 17, 1985) (Methanol/cosolvent alcohols/corrosion inhibitors); 47 Fed. Reg. 22404 (May 24, 1982) (Ethanol/Proprietary additive); 46 Fed. Reg. 56361 (November 16, 1981) (Methanol/GTBA/Oxygen); 45 Fed. Reg. 58954 (September 5, 1980) (TC-11064); 44 Fed. Reg. 37074 (June 25, 1979) (Methanol/TBA); 44 Fed. Reg. 12242 (March 6, 1979) (MTBE); 44 Fed. Reg. 10530 (February 21, 1979) (TBA); 44 Fed. Reg. 20777 (April 6, 1979) (Gasohol).

The Agency has denied waiver applications at 53 Fed. Reg. 2088 (January 26, 1988) (AM 5/5); 51 Fed. Reg. 28757 (August 11, 1986) (Petrocoal); 48 Fed. Reg. 52634 (November 21, 1983) (Methyl 10); 48 Fed. Reg. 8124 (February 25, 1983) (0-3% Methanol); 46 Fed. Reg. 58360 (December 1, 1981) (MMT); 45 Fed. Reg. 53861 (August 13, 1980) (Ethanol/Methanol); 45 Fed. Reg. 26122 (April 17, 1980) (Crude Methanol); 44 Fed. Reg. 1447 (January 5, 1979) (0-15% MTBE); 43 Fed. Reg. 41424 (September 18, 1978) (MMT).

Ethyl has prepared this waiver application in accordance with the standards established in these prior waiver proceedings. See American Methyl Corp., 749 F.2d at 839 (the court considers "EPA's past administrative practice as implementing the proper reading of section 211. . . ." (emphasis added)).

First, EPA has recognized that the cause or contribute standard established by § 211(f)(4) does not require an applicant to demonstrate that the fuel additive will not cause any increase in exhaust emissions. Motor Vehicles Mfrs. Ass'n of U.S. v. E.P.A., 768 F.2d 385, 390 (D.C.Cir. 1985). Rather, the applicant need only demonstrate that the fuel additive does not cause or contribute to a failure to meet emission standards. See Motor Vehicles Mfrs. Ass'n, 768 F.2d at 390 ("the Administrator is not required under section 211(f)(4) to adopt a 'no increase' standard").

Second, EPA has recognized that an applicant need not demonstrate that every vehicle, when using fuel containing the additive for which a waiver is sought, will meet emission standards. EPA has stated that such a burden would be "virtually impossible to meet as it requires the proof of a negative proposition, i.e., that no vehicle will fail to meet the emission standards with respect to which it has been certified. Taken literally, it would require the testing of every vehicle."[100/] Acknowledging that Congress intended to create a workable waiver

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[100/] See, e.g., DuPont Decision at 6; Grant of Application for a Fuel Waiver Submitted by the Synco 76 Fuel Corporation (Synco), EN-81-20 (May 18, 1982) (hereinafter "Synco 76 Decision") at 4-5; Grant of Application for a Fuel Waiver Submitted by the Atlantic Richfield Company, EN-81-10 (November 7, 1981) (hereinafter "Methanol/GTBA Decision") at 3-4; 45 Fed. Reg. at 58955 (September 5, 1980); In Re Application for Arconol, MSED-ZU(f)(4)-TBA (February 6, 1979) (hereinafter "Arco Decision") at 4; 44 Fed. Reg. at 37075 (June 25, 1979); 44 Fed. Reg. at 12243 (March 6, 1979).

provision, EPA has interpreted § 211(f)(4) to allow the waiver applicant to use "statistical sampling" and "fleet testing protocols" to meet the applicant's burden under this provision.[101]

Finally, the Agency has recognized that because of "the inherent limitations of using statistical methods to predict real-world situations. . . the appropriate criterion for granting a waiver under section 211(f)(4) is whether the results of testing under the statistical procedure indicate that use of the fuel or fuel additive will cause no <u>significant</u> failures of vehicles in a national fleet to meet emission standards."[102] In this way, the Agency can make practical judgments concerning the effects of a fuel or fuel additive on emissions to the atmosphere. Such judgments are important because, even if a fuel additive may have some detectable (i.e., "statistically significant") effect on exhaust emissions, this does not mean that the effect will be so important as to cause or contribute to the failure of emission control devices or systems.[103]

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[101] <u>See</u>, <u>e.g.</u>, Texas Methanol Decision at 8; DuPont Decision at 6; Synco 76 Decision at 5; Methanol/GTBE Decision at 4; Arco Decision at 5; 45 Fed. Reg. at 58955; 44 Fed. Reg. at 37075; 44 Fed. Reg. at 12243.

[102] Synco 76 Decision at 5 (emphasis added); <u>see also</u> Texas Methanol Decision at 8; DuPont Decision at 6; Methanol/GTBE Decision at 4.

[103] The Agency recognizes this distinction and, as explained more fully above, developed a two-part test to determine the practical effect of a fuel or fuel additive on exhaust emissions. <u>See supra</u> pp. 11-15. <u>See also</u> Appendix 10, at 1-3 (Whether a

(continued...)

These Agency interpretations have guided the formulation of the test programs and analyses described earlier in this waiver application. As discussed more fully below, these practical interpretations of the § 211(f)(4) waiver standard support granting this application.

C. <u>Ethyl Has Met the Statutory Standard.</u>

Ethyl has demonstrated both through statistical tests previously used by EPA and through additional statistical analyses that the Additive will not have a material adverse effect on exhaust emissions, and will not cause or contribute to the failure of emission control devices or systems to meet the emission standards for NOx, CO and HC.[104/] These analyses -- which show that use of the Additive results in substantial reductions in the emissions of NOx and CO -- call for the Agency to grant this waiver application.

The only observed increase in emissions for cars using the Additive in the test fleet occurred for HC emissions in the first 4000 miles of vehicle operation.[105/] As noted above, however, this very small increase in HC emissions did not cause or contribute to the failure of emission control systems in the test

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103/ (...continued)
change in tailpipe emissions is statistically detectable -- e.g., statistically significant -- is simply a function of the design of the test protocol. The ability to detect statistically small differences in emissions does not, by itself, mean that the detected difference has any practical, real world impact).

104/ <u>See supra</u> pp. 15-24.

105/ <u>See supra</u> pp. 18-19.

fleet to meet the HC emission standard. In addition to this crucial statistical result, the following information further explains why there is no basis to conclude that the slight HC emissions increase exhibited in the test program is material to a decision on this waiver application.

1. <u>When evaluated in light of real world conditions, the HiTEC 3000 Additive will not have a material impact on HC emissions or adversely affect ambient ozone concentrations.</u>

The Ethyl test program was run under carefully controlled conditions to isolate the effect of the Additive on exhaust emissions. As a result, the test data by itself do not fully reflect the potential impact of the Additive following its introduction into commerce. As discussed below, these "real world" conditions make the slight HC emissions effect of the HiTEC 3000 additive observed in the test program immaterial.

<u>The octane/aromatic effect</u> -- The Ethyl test program did not compare fuels of equal octane rating. Rather, in order to simplify the test protocol and to isolate the effect of the Additive on exhaust emissions, the test program compared a clear fuel with and without the Additive. Because the Additive enhances octane, the test fuel blended with the Additive had a higher octane rating than the clear fuel.

This octane imbalance in the test fuels is important because the octane rating of a fuel has a potentially significant effect on HC emissions. Aromatic compounds, which are typically used to enhance octane, are a significant source of automotive HC exhaust emissions. If the Additive is made commercially available, refiners will likely take advantage of the Additive's octane boosting properties by reducing the aromatic content otherwise necessary to achieve the octane specifications for their fuels.[106/] This is so because the HiTEC 3000 additive is a less costly method of boosting octane.[107/]

In recognition of these circumstances, Ethyl retained the well-respected oil industry analyst, Turner, Mason and Company, to analyze the effect of using the Additive on the refining industry. Among other things, Turner, Mason predicted that use of the Additive would result, at a minimum, in a decrease in the aromatic content of gasoline from 31.2 percent of gasoline volume to 30 percent.[108/] Other analysts predict that use of the Additive could reduce the aromatic content of gasoline by up to 2.0 percentage points by volume.[109/] This drop in aromatic content would cause a corresponding drop in HC tailpipe emissions -- an impact not reflected in Ethyl's test data.[110/]

[106/] See Appendix 6, at Attachment 6-1, p. 22.

[107/] See supra pp. 5-6.

[108/] See Appendix 6, at Attachment 6-1, p. 22.

[109/] Appendix 9, at Attachment 9-4.

[110/] See Appendix 10, at 4. At least three independent studies have concluded that HC tailpipe emissions can be reduced by reducing the aromatic content of unleaded fuels. See Appendix 9, Attachments 9-1, 9-2, and 9-3 (Colucci, J.M. An Investigation of the Effects of Gasoline Composition and Vehicle Systems on Exhaust Emissions, June 20-21, 1989; Piel, W.J., The Role of Ethers in Low-Emission Gasoline, National Conference on Motor

(continued...)

In order to evaluate further the effect of aromatics on HC emissions, Ethyl retained Southwest Research Institute ("SWRI") to conduct chemical speciation testing on the exhaust emissions from two of the cars from the test fleet fueled with test gasolines having the same octane rating.[111/] Equal octane ratings were achieved by adding either the HiTEC 3000 additive or mixed xylenes (a commonly used aromatic) to the test fuels.[112/] SWRI tested two model F cars from the Ethyl test fleet after they had accumulated approximately 66,000 miles. One of the vehicles ran on fuel blended with the Additive, and one ran on fuel blended with a small amount of mixed xylenes to equalize the octane rating. SWRI tested three different fuel blends to which either

110/ (...continued)
Fuels & Air Quality, October 3-5, 1989; and Prigent, M.J, et al. Engine Bench Evaluation of Gasoline Composition Effect on Pollutants Conversion Rate By a Three-Way Catalyst, International Congress and Exposition, Detroit, Michigan, February 26-March 2, 1990). For the same reason, the real world reductions in NOx and CO emissions would be greater than reflected by the test data.

111/ For a more detailed discussion of the speciation testing completed by SWRI, see Appendix 4.

112/ Ethyl added mixed xylenes to the test fuels to equalize octane because xylenes have a relatively low boiling point (285 °F). The low boiling point of xylene is important because it means that a greater percentage of the aromatic would be burned during the combustion process and not emitted from the tailpipe. Use of the mixed xylene, therefore, provides a conservative assessment of the possible effect of the Additive in gasolines with equal octane. If refiners using the Additive back out aromatics having higher boiling points, such as a heavy reformate or heavy cat-cracked gasoline, the resulting reduction in HC emissions would likely be even greater than that reflected in SWRI's speciation analysis.

the Additive or mixed xylenes had been added: Howell EEE, commercial gasoline, and reformulated gasoline.[113/]

The speciation testing on the model F cars shows that, after 1000 to 2000 miles, total HC emissions for the vehicle operating on the HiTEC 3000 blends were generally the same as, or less than, the HC emissions from the clear fuel vehicle blends.[114/] Moreover, in all cases, the emissions of nonmethane HC, aromatics, NOx, CO, benzene, and formaldehyde were <u>less</u> for the blends containing the Additive when compared to the clear-fuel blends.[115/] These test results support the conclusions of the independent studies cited above, and suggest that use of the HiTEC 3000 additive, by displacing aromatics, will not cause real world increases in HC tailpipe emissions.[116/]

<u>The ozone effect</u> -- Any statistically detectable HC emissions effect should also be evaluated in terms of the impact

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[113/] For each of the gasolines, the amount of xylene added to the fuel was approximately five percent by volume, while the amount of the Additive added was 0.03125 grams manganese per gallon. See Appendix 4, at Attachment 4-4.

[114/] HC emissions for the HiTEC 3000 vehicle operated on the reformulated fuel blend was a scant 0.004 gpm higher than clear fuel HC emissions. <u>See</u> Appendix 4, at Attachment 4-8.

[115/] <u>See</u> <u>id</u>. at Attachments 4-5 through 4-7.

[116/] <u>See</u> Appendix 10, at 4-5 (the displacement of aromatics resulting from use of the Additive would reduce HC tailpipe emissions by approximately 0.02 gpm, based on the results of independent studies).

of the HiTEC 3000 additive on ambient ozone concentrations.[117] In order to evaluate more carefully the overall impact of the Additive on ambient ozone, Ethyl retained SAI to evaluate, using the Urban Airshed Model (UAM), the impact of NOx and HC emissions changes on ozone concentrations. This program is summarized below and discussed in detail in Appendix 5.

Briefly, the UAM is used by EPA to portray the dispersion and chemical reactions of substances that contribute to ozone formation. SAI used as input to this model the HC and NOx emissions data for mobile sources developed by Ethyl through its 75,000 mile emissions testing program, and the refinery emissions information based on the Turner, Mason analysis.[118] Since the operation of this model further depends on the reactivity of specific HC compounds, SAI also relied on the chemical speciation testing conducted for Ethyl by SWRI.[119]

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[117] When Congress, in 1965, first directed that an emissions standard be established under the Clean Air Act to control HC emissions, its major concern with automobile emissions was the formation of ozone, "a highly poisonous variety of oxygen." 1965 U.S. Code Cong. & Admin. News 3608, 3611. Congress reaffirmed this concern when it amended the Act in 1970, and again in 1977. See, e.g., 1977 Legis. Hist. at 746 ("Hydrocarbons emitted into the air from automobiles react with nitrogen oxides . . . in the atmosphere to form photochemical oxidant -- smog. . . . There is general agreement that the 0.41 hydrocarbon standard should be imposed as rapidly as possible to mitigate the pervasive smog problem." (Statement of Senator Muskie (D-MA)).

[118] The methodology used by SAI to incorporate these emissions data into MOBILE 4 is presented in Appendix 5. A discussion of the Turner, Mason refinery emission analysis can be found infra at 63.

[119] See Appendix 4.

The SAI analysis examines ambient ozone concentrations with and without use of the Additive in fuel in two areas of the country for the year 1994. The areas chosen for this analysis were Philadelphia and Atlanta -- areas that currently do not attain the ozone ambient standard, that are influenced by mobile source and/or refinery emissions, and that have relatively high background concentrations of HC.[120/] The year 1994 was chosen for analysis to allow time for market penetration by the Additive.

For each of these cities, SAI performed two sets of UAM simulations designed to assess the effect of using the Additive on urban air in two different ways. For both sets of simulations, the mass emissions from light duty gasoline vehicles (LDGVs) were based on the EPA Mobile-4 emission program for the base case simulations and on the Mobile-4 emission program with the deterioration rates modified to reflect the use of the Additive for the HiTEC 3000 simulations.

In the first set of simulations, the speciation of HC emissions from the LDGVs was based on the speciation program described in Appendix 4 to this waiver application. Specifically, for the HiTEC 3000 simulation, SAI applied data reflecting commercial fuel plus HiTEC 3000 speciation,[121/] whereas the base case simulation applied data on commercial fuel plus

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[120/] It should be noted that other ozone nonattainment areas share these same basic characteristics. See Appendix 5, at 9 (Table 2-1) and 10 (Figure 2-1).

[121/] See id. at 37-40.

mixed xylenes speciation.[122/] For the second set of simulations, SAI used the EPA recommended speciation for LDGVs from the Air Emissions Speciation Manual (AESM).[123/]

The results of both sets of simulations for Philadelphia and Atlanta show that use of the Additive will not adversely affect peak ozone ambient concentrations. To the contrary, use of the Additive could marginally improve the peak ozone level (on the order of 0.5 parts per billion), and the population exposed to the predicted peak ozone level, in both cities.[124/] SAI therefore concludes that "the use of HiTEC 3000 will in no way endanger attainment of the ozone NAAQS and may in fact even help a little."[125/]

2. The very small HC emissions effect observed in the Ethyl test program will have no real world impact in light of other larger sources of variability in HC emissions.

Ethyl has conducted a statistical analysis which establishes that the largest source of variability in HC emissions in Ethyl's

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[122/] Id.

[123/] Id.

[124/] Id. at 60, Table 5-1. The marginal predicted improvement in peak ozone concentrations applies for Philadelphia under both sets of simulations, and to Atlanta using the results of Ethyl's speciation program. Id. at 67, Table 5-5. Atlanta shows a marginal (0.3 ppb) increase in peak ozone concentrations using EPA's AESM speciation profiles. The marginal improvements in peak ozone concentrations resulting from use of the Additive would be the equivalent of removing 170,000 cars from the streets of Philadelpia and 129,000 cars from Atlanta. Id. at 68.

[125/] Id. at 70.

test program is attributable to the various car models, not the type of fuel used in a car.[126] This car model effect is highlighted by subdividing Ethyl's test fleet into "high" and "low" emitter classes. The high emitters (models D, F and T) are the cars that exceed the 0.41 gpm HC standard on both clear and Additive fuel within the first 50,000 miles of vehicle operation. The remaining car models are classified as low emitters. The clear fuel HC emissions averaged 0.420 and 0.186 gpm for the high and low emitters, respectively.[127] This difference of 0.234 gpm is more than 13 times larger than the very small HC emission increase observed for vehicles using the Additive in Ethyl's test fleet.

Moreover, even if the analysis is limited to the low emitter class of car models (i.e., those models which complied with the 0.41 gpm HC emission standard for the first 50,000 miles), the variation in HC emissions is still substantial. Average HC emissions for clear-fuel model H cars, for example, was 0.271 gpm.[128] Average HC emissions for clear-fuel model G cars was only 0.129 gpm.[129] The difference in average HC emissions from these two car models is 0.142 gpm, an emission level almost eight

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[126] See Appendix 10, at 8-9.

[127] Id., at Attachment 10-2.

[128] Id.

[129] Id.

times larger than the small HC emissions increase observed in Ethyl's test program for the HiTEC 3000 cars.

What this means as a practical matter is that variations in the composition of the automotive fleet from year-to-year have a far more significant effect on HC emissions than any possible effect attributable to use of the Additive in unleaded gasoline.

3. Other waiver applications approved by EPA support approval of this application.

As noted above, the Agency has previously applied the § 211(f)(4) waiver standard to focus on the practical importance of the emissions effect of the fuel additive being evaluated. In so doing, the Agency has approved waiver applications where there have been small but measurable increases in emissions of a regulated pollutant that the Agency has judged not to be practically important. In some cases, these increases have been greater than the minuscule HC emissions effect observed in Ethyl's test program.

In the DuPont Decision,[130/] for example, the Agency approved a waiver request for a DuPont fuel additive that caused a 0.017 gpm increase in HC emissions, or an increase of almost 9 percent over the baseline HC emissions test data.[131/] The average HC

[130/] See supra note 15.

[131/] The fuel at issue (number 87 in the application documents) had the same volatility as Indolene, plus 5 percent methanol and 2.5 percent gasoline grade t-butyl alcohol. The fuel was one of eleven blends which the Agency considered, as a group, to meet the standard under CAA § 211(f)(4). See DuPont Decision, at 10.

The specific intent of Congress to encourage the development of fuels and fuel additives that reduce atmospheric loadings, and the broader goal of Congress to encourage consideration of the overall social, economic, and environmental implications of regulatory decisions regarding mobile sources, support a pragmatic approach to evaluation of waiver applications. As discussed below, evaluation of the HiTEC 3000 additive shows that it has overall beneficial environmental, economic and energy impacts. This further supports approval of this waiver application.

A. <u>The Use of the HiTEC 3000 Additive Will Have A Beneficial Impact on Emissions and Ambient Concentrations of Air Pollutants.</u>

1. <u>Mobile and stationary source emissions</u>

As discussed above, Ethyl's lengthy test program shows that the Additive will have a positive impact on mobile source exhaust emissions. NOx emissions from mobile sources will decrease substantially with use of the Additive, by up to 633 million pounds per year by 1999. CO emissions will also decrease by up to 985 million pounds annually by 1999. HC emissions will change little, if any, and will decrease as the Additive is substituted

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152/ (...continued)
broad goals which Congress intended it to effectuate." The court acknowledged that the "broad purpose of the Clean Air Act Amendments of 1970 is plain: 'to protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population[.]'" <u>Chrysler Corp.</u>, 631 F.2d at 888. <u>See also General Motors Corp. v. Ruckelshaus</u>, 742 F.2d 1561, 1572 n. 15 (D.C. Cir. 1984).

emission increase exhibited by the specific fuel blend in the DuPont Decision is roughly two times higher than the increase associated with the Additive in Ethyl's test program, measured as a percentage increase over average baseline HC emissions.

As another example, Synco 76 received a waiver for a "gasohol" variant based on test data from only eight vehicles showing average baseline NOx emissions of 0.899 gpm. By comparison, the average NOx emissions for these vehicles when fueled with gasohol were 1.085 gpm. The Synco 76 additive therefore resulted in an average increase in NOx emissions of 0.186 gpm, or almost 20 percent over the baseline.[132/] This percentage increase is far greater than that indicated for HC in the Ethyl test program, even if no adjustment is made to account for the potential reduction in aromatics made possible by use of the Additive. If, as the Agency concluded, the NOx increase associated with use of the gasohol variant was "modest," any possible, small increase in HC emissions associated with the Additive must be considered even more "modest."[133/]

[132/] See Synco 76 Decision. A Congressional Research Study completed in May of 1987 concludes that emission studies of oxygenated gasoline blends show that "[n]itrogen oxide (NOx) emissions are apparently increased" by use of the oxygenates. Gushee, D.E., Emissions Impact of Oxygenated (Alcohol/Gasoline) Fuels, Congressional Research Service Report for Congress, 87-436S (May 20, 1987).

[133/] Synco 76 Decision. In the DuPont Decision, the Agency also approved use of several fuel additive combinations notwithstanding the fact that their use resulted in average increases in NOx ranging from 0.03 gpm to 0.05 gpm, or approximately three to five percent of baseline NOx emissions.

(continued...)

In sum, small increases in one regulated pollutant have not defeated a waiver application so long as the fuel additive satisfies the statistical tests used by the Agency under CAA § 211(f) to assess the effect of the additive on emission control devices. Applying this same approach, the extremely small, and probably overstated, increase in HC emissions here provides no basis for denying this waiver application. Rather, given the overall beneficial environmental effects of the Additive,[134/] the congressional objective of encouraging the use of promising fuel additives, and the Agency's prior implementation of the statutory standard, the Agency should grant this waiver application.

IV. THE HiTEC 3000 ADDITIVE SHOULD NOT CAUSE OR CONTRIBUTE TO THE FAILURE OF VEHICLES TO MEET STRICTER EMISSION STANDARDS UNDER PROPOSED CHANGES TO THE CLEAN AIR ACT.

The emission standards to which the Agency must look in making a determination on Ethyl's waiver application are the existing standards under the Clean Air Act.[135/] Nevertheless,

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133/ (...continued) See DuPont Decision (DuPont fuel combinations identified as numbers 85, 94 and 95 in the DuPont application documents).

134/ See infra pp. 60-67.

135/ The relevant inquiry under § 211(f) of the Act is "the 'first' introduction of new fuels and new fuel additives into commerce." American Methyl Corp. v. EPA, 749 F.2d 826, 836 (D.C. Cir. 1984). Because the focus of § 211(f) is on the first introduction of new fuels and additives into commerce, the only emission standards to which § 211(f)(4) applies are, by definition, existing standards -- i.e., those "to which [any vehicle] has been certified pursuant to section 206." CAA § 211(f)(4) (Emphasis added).

(continued...)

Congress is currently considering amendments to the Clean Air Act that could include stricter emission standards for motor vehicles. For this reason, Ethyl has examined the implications of the Additive for more stringent emission standards.[136/]

As noted elsewhere, use of the Additive reduces emissions of nitrogen oxide (NOx) and carbon monoxide (CO) from

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[135/] (...continued)

This does not mean, however, that the Agency is without authority to regulate fuel additives that receive a waiver, if the Agency later determines that the additive adversely affects compliance with future emission standards. Under § 211(c) of the Act, the Agency has general authority "to 'control or prohibit the manufacture. . . or sale of any fuel or fuel additive' in order to reduce harmful air pollution and to maintain the performance of emission control equipment." American Methyl Corp., 749 F.2d at 836.

Indeed, the courts have recognized that § 211(c) is the proper source of authority for subsequently regulating fuels that have received a waiver under § 211(f)(4). See id. at 834 ("the Administrator must initiate appropriate proceedings pursuant to section 211(c) if he wants to control or prohibit a fuel or fuel additive waived into commerce"). Thus, "the interrelationship of [§§ 211] (f) and (c) -- with subsection (f) regulating the 'first' introduction of fuels and fuel additives into commerce and subsection (c) governing the control or prohibition of fuels and fuel additives already in commerce -- gives effect to the requirements of each subsection and comports with Congress' understanding of their interdependence." Id. at 834.

[136/] The standards used in this analysis vary depending upon the mileage accumulated on the vehicle. For the first 50,000 miles of operation, the standards assumed to apply are 0.31 gpm for total HC and 0.25 for non-methane HC, 0.4 gpm for NOx, and 3.4 gpm for CO. For 50,000 to 75,000 miles, the standards assumed to apply are 0.39 gpm for total HC and 0.31 gpm for non-methane HC, 0.5 gpm for NOx, and 4.2 gpm for CO. These standards play a prominent role in both the legislation approved by the House Energy & Commerce Committee (H.R. 3030) and the Senate/Administration compromise legislation (S.1630).

automobiles.[137] Moreover, by enabling the use of lower aromatic content fuel, the Additive may also help to reduce HC emissions and the reactivity of those emissions.[138] Because of these effects, the Additive should help automobile manufacturers attain compliance with any future, more stringent NOx or CO standards without adversely affecting compliance with any more stringent HC standard.[139]

In order to analyze these effects, Ethyl chose five models from its test fleet that could meet the existing 0.41 gpm HC standard over 50,000 miles.[140] These models are car models C, E, G, H and I. Ethyl then asked SAI to conduct statistical analyses on the test data from these models to evaluate compliance with the stricter, proposed emission standards.[141] The results of these analyses are described briefly below, and discussed in more detail in Appendix 11.

Only three of the nine statistical tests used by EPA to determine the long-term deteriorative impact of an additive on

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137/ See Appendix 2A, at D-26 and D-27; Appendix 2B, at 6, Table 1-2.

138/ See Appendix 5, at 32; Appendix 10, at 3.

139/ See supra pp. 46-49.

140/ Since no emission control systems are currently designed to meet the proposed, more stringent HC and NOx standards, Ethyl focused for purposes of this analysis on systems designed to meet the current standards, which in fact can meet those standards. This criterion resulted in inclusion of five of the eight models tested by Ethyl in this further analysis.

141/ See Appendix 11.

tailpipe emissions consider specific emission standards. These tests are (1) the violation mileage test; (2) the maximum percentage of vehicles failing the standard test; and (3) the pivotal cause or contribute test. SAI applied these three tests, together with the mean effects analysis described in Appendix 2A, to the data for models C, E, G, H, and I.[142/]

Applying these tests using the stricter emission standards noted above, no overall adverse effects are seen in any of the violation mileage or maximum percentage of vehicles failing the standard tests.[143/] In addition, the group of five models pass all cause or contribute tests.[144/] This implies that use of the Additive will not cause or contribute to the failure of emission control devices or systems to meet the stricter emission standards currently under congressional consideration for application in the mid-1990's.

Indeed, SAI's mean effects analysis shows that while clear-fueled cars do not, on a weighted-average basis, meet either the 50,000 mile or 100,000 mile NOx standards, the cars using the Additive do meet these standards.[145/] The mean effects analysis

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142/ See Appendix 11, at Attachment 11-1. SAI performed each of the three EPA tests in three different ways -- 50,000 mile analysis based on linear regression, 50,000 mile analysis based on quadratic regression, and 75,000 mile analysis based on quadratic regression.

143/ Id. at 4-6.

144/ Id. at 4-7.

145/ See id. at 5.

also shows that both the clear-fueled and Additive-fueled vehicles will meet the 4.2 gpm CO standard at 75,000 miles.[146/] Finally, the mean effects analysis shows that, regardless of the vehicle's fuel type, the five models comply, on a weighted-average basis, with the stricter HC emission standards at both 50,000 miles and 75,000 miles.[147/]

Together, the SAI analyses suggest that use of the HiTEC 3000 additive will not cause or contribute to the failure to meet the stricter emission standards currently being considered by Congress for application in the mid-1990's and beyond.

V. CONSIDERATION OF OTHER ENVIRONMENTAL, ECONOMIC AND ENERGY IMPACTS SUPPORT APPROVAL OF THE WAIVER APPLICATION.

When Congress originally enacted the Clean Air Act in 1963, it described the purposes of the Act as including the need "to encourage continued efforts on the part of the automotive and fuel industries to develop devices <u>and fuels to prevent pollutants from being discharged from the exhaust of automotive vehicles</u>."[148/] This objective was carried forward in the 1970 Amendments to the Clean Air Act, and is reflected in Congress'

[146/] <u>Id.</u> at 6. While both the clear-fueled and Additive-fueled vehicles fail to meet the 3.4 gpm standard at 50,000 miles on a weighted-average basis, average CO emissions for the Additive-fueled vehicles are <u>below</u> those for the clear-fueled vehicles at the 50,000 mile test interval. <u>Id.</u>

[147/] <u>Id.</u> at 7.

[148/] Conference Rep. No. 1003, 88th Cong., 1st Sess. (December 5, 1963), <u>reprinted in</u>, 1963 U.S. Code Cong. & Admin. News 1260, 1280 (emphasis added).

direction to the Agency to "give special emphasis" to research and development of new fuels and fuel additives "which, when used, result in a decrease in atmospheric emissions."[149] This legislative history signals a clear congressional intent that improved fuels and fuel additives play a role in meeting the broader environmental goals of the Act.

When it amended the Act in 1970, Congress also stated that the overall goal of the Act is "to protect and enhance the quality of the Nation's air" in a way that "promote[s] the public health and welfare and the productive capacity of its population."[150] As the Agency has recognized, a "balancing of the social and economic considerations with the environmental implications [of a decision is necessary] . . . to fulfill the mandate of the Clean Air Act to 'protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population.'"[151] The courts have expressly recognized that the mobile source provisions of Title II must be construed in light of these broader goals of the Act.[152]

149/ 42 U.S.C. § 7404(a)(1)(E).

150/ See 42 U.S.C. § 7401(b)(1).

151/ 39 Fed. Reg. 31,000 col. 1 (Aug. 17, 1974) (emphasis added).

152/ In Chrysler Corp. v. U.S. Environmental Protection Agency, 631 F.2d 865, 888 (D.C. Cir. 1980), for example, the court refused to interpret the automotive recall provision of section 207 of the Act "in a manner which runs counter to the

(continued...)

for aromatics to achieve required octane levels. Benzene and formaldehyde emissions also will be reduced significantly. Considered together, the use of the Additive could result in a net reduction of mobile source emissions of these pollutants of up to 1.6 billion pounds per year by 1999.[153/]

Increased use of the Additive will also have a beneficial impact on stationary source emissions of NOx, CO, and other substances. As noted, Ethyl retained Turner, Mason & Company ("Turner Mason") to evaluate the potential impact of the Additive on refinery emissions.[154/] Among other things, Turner Mason concluded that since the Additive is an octane enhancer, the use of this additive will allow refineries to reduce the degree to which they must process oil. This means, in turn, that refinery emissions will be reduced.

The Turner Mason analysis shows that use of the Additive would reduce refinery emissions of NOx by up to 11 million pounds per year, and of CO by up to 3 million pounds per year. Emissions of other compounds would fall as well: particulates by over 1 million pounds annually; sulfur oxide by 150,000 pounds annually; and carbon dioxide by almost 10 billion pounds annually.[155/]

153/ See Appendix 7, at Attachment 7-5 and 7-6.

154/ See supra p. 47. The Turner Mason analysis is presented in Appendix 6, at Attachment 6-1.

155/ Appendix 6, at Attachment 6-1, p. 3.

In addition, when refining gasoline from crude oil, highly volatile materials such as butanes are produced. Although butane enhances octane, it also raises the vapor pressure of gasoline. Gasoline with a high vapor pressure can contribute to increased evaporative and running losses from vehicles in hot weather. Because the Additive enhances the octane of unleaded gasoline about one octane number, butane production can be reduced, making it less difficult to meet lower vapor pressure specifications for gasoline.[156/]

2. <u>Ambient concentrations</u>

These reductions in mobile and stationary source emissions will reduce ambient concentrations of and population exposure to these pollutants. To examine these impacts, Ethyl retained SAI to conduct air quality modeling analyses based on the projected emissions changes associated with the use of the Additive. The SAI analyses are described in Appendix 5 to this application, and are summarized below.

a. <u>NOx and CO ambient concentrations</u>

As noted above, mobile and stationary source emissions of NOx after approval of the Additive could decrease by up to 644 million pounds per year by 1999.[157/] These emissions decreases will have a corresponding beneficial impact on ambient concentrations of this pollutant.

156/ <u>Id.</u> at Table 26.

157/ <u>See</u> Appendix 7.

Based on EPA-approved air quality modeling techniques, SAI estimates that, in an urban area influenced by mobile source and refinery emissions, use of the Additive would marginally improve ambient concentrations of NO2.[158] With respect to CO emissions, Ethyl's mobile source analysis shows mobile and stationary source emission reductions in the range of 988 million pounds per year by 1999.[159] These reductions could also have a potentially beneficial impact on ambient CO concentrations.[160]

b. Ozone ambient impacts

In order to analyze the implications of changes in NOx and HC emissions resulting from HiTEC 3000 for ozone formation, SAI conducted an atmospheric modeling analysis using the Urban Airshed Model (UAM). This analysis shows that even if one assumes that the small increase in HC emissions shown in the Ethyl test program will occur in commercial operation and will consist of reactive HC, these small HC increases will not affect ambient ozone levels in light of the simultaneous NOx emission decreases.[161] When one accounts for (1) the likely reduction in HC emissions associated with reduced aromatics in gasoline,[162] and (2) the less reactive HC mix associated with use of the

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[158] Appendix 5, at Table 5-4.

[159] See Appendix 7.

[160] Id.

[161] See supra pp. 49-52.

[162] See supra pp. 46-49.

Additive,[163] the UAM analysis shows that use of the Additive could actually reduce ambient ozone concentrations in some areas.[164] In sum, any small changes in HC emissions associated with use of the Additive will not adversely affect, and could have a beneficial effect on, ambient ozone concentrations.

c. Other significant air pollutants

SAI also evaluated the potential reductions in ambient concentrations of other significant air pollutants such as benzene that would result from the use of the Additive. The SAI analysis shows that, in areas of the country with high mobile source concentrations, the use of the Additive could result in reductions in benzene concentrations of up to 10 percent over time.[165] Given EPA's recent efforts under the Clean Air Act to control benzene emissions,[166] such reductions in benzene concentrations are a desirable effect of using the Additive. Ambient concentrations of formaldehyde could also be expected to

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163/ See Appendix 5, at 32.

164/ Id. at 52-63.

165/ Id. at 65.

166/ See, e.g., 54 Fed. Reg. 38044 (September 14, 1989). The costs of the benzene controls recently required by EPA are substantial. EPA estimated the capital costs to control benzene emissions to acceptable levels from coke by-product recovery plants alone would be $74 million, with an annualized cost of $16 million. By contrast, the significant reductions in the emission of benzene associated with use of the Additive can be obtained at no additional cost.

drop since formaldehyde emissions could fall by up to 3.5 million pounds annually by 1999.[167]

3. Manganese Emissions

Use of the Additive at the concentration proposed in this waiver application will result in infinitesimal additional emissions of manganese. Based on testing of vehicles in the Ethyl test fleet, a current model automobile fueled on gasoline with the Additive would release about 0.06 grams (0.00006 kilograms) of manganese on an annual basis, assuming the car was driven 12,000 miles in a year and consumed fuel at the rate of 25 miles per gallon.[168] Under these assumptions, only about 0.5 grams of manganese would be emitted over the course of 100,000 miles of vehicle operation.

As a result of these exceedingly small emissions, the Additive will have virtually no impact on ambient concentrations of manganese. For example, in a typical large urban area like Philadelphia, one could expect, conservatively, maximum increased ambient concentrations of manganese of only about 0.0009 ug/m^3.[169]

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[167] *See* Appendix 7, at 1.

[168] *See* Appendix 8, at 5-6.

[169] SAI calculated the maximum manganese concentration attributable to use of the Additive. SAI estimated this concentration by taking the ratio of manganese tailpipe emissions to CO tailpipe emissions and applying this ratio to the maximum calculated CO concentration. *See* Appendix 5, at 65.

By way of comparison, EPA has estimated that large point sources could cause maximum ambient manganese concentrations of over 100 ug/m^3.[170/]

Moreover, data from the U.S. National Air Surveillance Network show that ambient concentrations of manganese in the urban ambient air have been about 0.03 to 0.04 ug/m^3 during the 1970s and 1980s.[171/] These data, as well as ambient monitoring data from Canada (where the Additive has been used in virtually all unleaded gasoline for over a decade), suggest that ambient concentrations are a function of normal background concentrations and large point sources, and that the infinitesimally small emissions associated with use of the Additive has had no discernable effect on ambient manganese concentrations.[172/]

From a public health standpoint, manganese is one of the essential trace elements that man requires to sustain life. It is present naturally throughout our environment, and is present in trace quantities in the cells of all living organisms.[173/] Without the presence of manganese in the body, several reactions essential for life cannot occur.[174/]

170/ See Appendix 8, at 3.

171/ See id. at 3-4.

172/ See id. at 7-8.

173/ See id., at 1-5.

174/ See id. at 1-2, 8-10.

Given that manganese is present in our everyday environment and is an essential nutrient, and that use of the Additive will not have a discernable effect on ambient manganese concentrations, manganese emissions associated with use of the Additive will have absolutely no adverse effect on public health.[175] This conclusion is confirmed by the repeated investigations of EPA and other respected environmental authorities. These authorities have consistently found that there is no carcinogenic effect in humans associated with low level emissions of manganese, and that noncarcinogenic effects occur only at work place concentrations in excess of 5,000 ug/m^3 on an 8-hour basis -- a level over 100,000 times greater than the 0.02 to 0.04 ug/m^3 concentrations characteristic of ambient air in rural and urban environments, and over 5 million times greater than the maximum concentrations conservatively predicted to be associated with use of the Additive.[176]

175/ See id. at 8-10.

176/ See id. at 10-13. EPA and its science advisers have concluded after extensive analysis, that, "public exposure to manganese is presently far below any level associated with non-carcinogenic serious health effects, and . . . evidence currently available does not indicate that manganese is carcinogenic." 50 Fed. Reg. 32627 (1985). Moreover, EPA's studies have shown that concentrations of manganese in the ambient air, "even in the vicinity of major manganese emitting facilities" such as ferroalloy producers, are adequately limited by EPA's NAAQS for particulate matter to levels far below those that would produce even minor health effects. See id. at 32627-28; EPA Final Health Assessment Document for Manganese, pp. 6-7.

Finally, it should be noted that the Additive itself has been the subject of extensive health studies, all of which have (continued...)

B. The Use of the HiTEC 3000 Additive Will Have Beneficial Economic and Energy Consequences for the Nation.

As noted at the beginning of this waiver application, one of the chief advantages of the HiTEC 3000 additive is that it enhances octane at a cost which is about one-third the cost of competing methods of enhancing octane.[177/] In a competitive gasoline market, at least a portion of these cost savings will be realized by consumers at the gasoline pump, allowing consumers to spend more of their income in other productive ways. This result should be beneficial to the U.S. economy.

In addition, use of the Additive will allow refineries to operate under less severe conditions. As a direct consequence, the Additive could result in a reduction in crude oil imports of about 30 million barrels per year. At $18 per barrel, this amounts to a reduction in imports of nearly $540 million per year.[178/] Moreover, this savings in crude oil is nearly equal to the amount of oil stored each day in the Strategic Petroleum Reserve.[179/]

176/ (...continued) shown that it presents no hazard to public health from use in gasoline.

177/ See supra pp. 5-6.

178/ See Appendix 6, at 5. Alternatively, use of the Additive would cut capital investment in octane producing units by nearly $750 million per year. Id. at 7.

179/ See Appendix 6, at Attachment 6-2.

In sum, the use of the HiTEC 3000 additive would have substantial economic and energy benefits for this nation. These energy and economic consequences of the Additive are yet additional factors supporting expeditious approval of this waiver application.

V. CONCLUSION

The HiTEC 3000 additive will not cause or contribute to the failure of emission control devices or systems to meet applicable emission standards. In fact, it will result in significant reductions in emissions and ambient concentrations of regulated air pollutants. Moreover, the Additive will cause no deterioration in vehicle driveability, automotive materials, or in evaporative emissions. Finally, the Additive will have beneficial energy and economic implications for this nation.

Nearly twenty years ago, Congress directed EPA to give special emphasis to the development of fuel additives that result in improvements in atmospheric emissions. For the reasons discussed above, the HiTEC 3000 additive provides a safe, readily available, and economically attractive emissions control alternative. Granting this waiver application will further Congress' specific objectives in the fuel additive provisions of the Act, as well as the broader congressional objectives "to promote the public health and welfare and the productive capacity" of this nation's population.

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TECHNICAL MEMORANDUM

TO: Ethyl Corporation

FROM: Ralph L. Roberson, P.E. *Ralph L. Roberson*

DATE: June 19, 1991

SUBJECT: Review of Specific Fuel Effects on Tailpipe Emissions

BACKGROUND

During a May 1991 meeting between EPA representatives and Ethyl representatives, the Agency provided Ethyl with a data sheet (see Attachment 1) that summarizes the results of testing completed by EPA on a 1991 Dodge Dynasty. In general, EPA's tests show an increase in gaseous and particulate emissions when HiTEC 3000 is added to a Sun certification fuel. One test conducted with Howell EEE plus HiTEC 3000 yields results similar to those obtained for Sun certification fuel without HiTEC 3000. Based on these results, some EPA representatives stated that they believe the effect of HiTEC 3000 on emissions may be fuel specific. Moreover, EPA stated that the results obtained for the Dodge Dynasty are consistent with those obtained by the Agency during its 1990 manganese testing program.[1] The purpose of this memorandum is to review existing data to evaluate the accuracy of EPA's statements. Based on the discussion below, we do not believe that HiTEC 3000 has fuel specific effects on gaseous emissions (including any fuel specific instantaneous effects).

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1 EPA Memorandum -- MMT Testing Program Report from J. Bruce Kolowich, Fuels and Chemistry Services to Mary T. Smith, Field Operations and Support Division, dated October 29, 1990.

EPA'S 1990 TESTING PROGRAM

For EPA's 1990 testing program, the Agency tested a total of 15 vehicles. Six of the vehicles were from Ethyl's 48 car test fleet, three were leased from a Canadian rental agency, and six were leased from a U.S. rental agency. In EPA's test report, the three groups of cars are referred to as: "Ethyl Test Vehicles," "Canadian Vehicles," and "American Vehicles." For the purpose of comparing emissions, we believe that the 1991 Dodge Dynasty should be compared to the results obtained for the group of "American Vehicles." That is, the 1991 Dodge Dynasty and the "American Vehicles" are all relatively low mileage cars and, unlike the "Canadian Vehicles," had no previous mileage accumulation with manganese in the fuel.

To analyze EPA's 1990 data, we propose simply to compute an arithmetic average emission rate based on all tests with manganese in the fuel and an arithmetic average emission rate based on all tests without manganese in the fuel for each of the six vehicles. Finally, we average across all six test vehicles. To be consistent with the summary calculations contained in EPA's test report (as well as the Ethyl fleet test data), we use gaseous emission measurements obtained for the FTP driving cycle. Average emissions for the six "American Vehicles" are tabulated below.

	Average Emissions (g/mile)	
	With Manganese	Without Manganese
Average FTP HC	0.199	0.198
Average FTP CO	2.688	2.583
Average FTP NO_x	0.378	0.389

Based on the above calculations, we conclude the results obtained for the regulated gaseous pollutants based on EPA's 1991 testing of a 1991 Dodge Dynasty are <u>inconsistent</u> with the results obtained by EPA in its 1990 test program. That is, EPA's 1990 results show only an infinitesimal HC increase of 0.001 g/mile. Moreover, CO emissions exhibit a relatively small increase (0.105 g/mile), and NO_x emissions with manganese in the fuel are 0.011 g/mile <u>less</u> than for clear fuel. It is interesting to observe that not only is the average increase in HC emissions very small, but the range in HC emission differences is also small. The largest HC increase for any one vehicle in the six car fleet is 0.012 g/mile, but one vehicle exhibited a HC decrease of 0.012 g/mile.

Lastly, we observe that EPA's 1990 test fleet of "American Vehicles" also included a 1991 3.3L Dodge Dynasty, the same car model EPA used in its 1991 testing. This vehicle was tested once with clear fuel and five times with the HiTEC 3000 additive during late 1990. EPA's 1990 results for the FTP driving cycle are summarized below.

	Single Test Without Manganese	Five Tests With Manganese
Average FTP HC	0.290	0.298
Average FTP CO	2.137	2.011
Average FTP NO_x	0.423	0.423

Again, the above results are very inconsistent with those reported by EPA for its 1991 testing of another 1991 Dodge Dynasty. We believe therefore that it is not accurate to characterize the gaseous emission testing completed by EPA in 1991 as consistent with the 1990 EPA test results. The 1990 EPA test results described above do not show adverse effects on gaseous emissions.

SWRI SPECIATION TESTING

During 1990, Southwest Research Institute (SwRI) conducted speciation testing on a pair of cars from Ethyl's 48 car test fleet.[2] At the time of speciation testing, the two cars (one operated on Howell EEE and one operated on Howell EEE plus HiTEC 3000) had accumulated approximately 67,000 miles as part of the Ethyl test fleet. The results of this testing, discussed below, do not support the claim that HiTEC 3000 may have fuel specific emission effects.

SwRI tested both cars on three base fuels: Howell EEE and two commercial fuels: regular Texaco and ARCO EC-1. SwRI conducted a total of four FTP driving cycle tests on each of the three base fuels. Also, all of the tests on the car using the HiTEC 3000 fuel additive were conducted with HiTEC 3000 in the fuel at the time of testing.

In assessing whether the effect of HiTEC 3000 on regulated emissions is fuel specific, we believe it is instructive to examine the emission measurements obtained by SwRI for the car that was tested with the HiTEC 3000 fuel additive. We have computed the arithmetic average and standard deviation of the four tests for the three base fuels for the regulated gaseous pollutants. These results are tabulated below.

	Average and [Standard Deviation] Emissions (g/mile)		
Base Fuel	HC	CO	NO_x
EEE	0.51 [.04]	1.38 [.07]	.94 [.02]
Texaco	0.49 [.03]	1.50 [.30]	.86 [.05]
ARCO	0.57 [.05]	1.61 [.20]	.98 [.03]

2 Effects of MMT on Exhaust Hydrocarbon Emissions -- 1988 Ford Crown Victoria, prepared by Southwest Research Institute, San Antonio, Texas 78228, April 1990.

The above-tabulated results obtained by SwRI do not support the statement that the effect of HiTEC 3000 on regulated gaseous emissions is fuel specific. In fact, accounting for the variability in tailpipe emissions, SwRI results show that emissions are about the same regardless of the base fuel to which HiTEC 3000 is added.

OTHER HISTORICAL DATA

Other studies have been conducted that also address the issue of specific fuel effects, including any fuel specific instantaneous effects, of the HiTEC 3000 fuel additive. For example, a Coordinating Research Council (CRC) study examined the instantaneous effect of HiTEC 3000 by testing cars with Mn-spiked Indolene as well as with clear Indolene at 300 and 22,500 miles. Indolene is a certification fuel and has essentially the same characteristics as the test fuel used by EPA in conducting the 1991 Dodge Dynasty tests.

Tabulated results obtained for the CRC tests are provided in Attachment 2. While emission control technologies are different now from those employed at the time of the CRC tests, the CRC test data remain instructive with respect to the reported engine-out data. The engine-out data with 1/32 gram of manganese per gallon of Indolene (the concentration at issue for Ethyl's waiver application) show <u>lower</u> engine-out emissions for vehicles operating on HiTEC 3000 fuel at both 300 and 22,500 miles. These results suggest that there are no fuel specific effects, including instantaneous fuel specific effects associated with use of HiTEC 3000.

Finally, in 1986, Ethyl evaluated the effect of HiTEC 3000 on emissions for vehicles used in Australia.[3] Several cars were tested with and without HiTEC 3000. The base fuel was one that conforms to Australian Design Rule 37A, which requires an unleaded fuel with a Research Octane Number between 91 and 93. All vehicles had accumulated at least 10,000 kilometers prior to testing. Generally, each car was tested three times with the base fuel and three times with the base fuel plus the HiTEC 3000 additive. Average emissions as determined for six cars are shown below.

	Average Emissions (g/mile)	
	With Manganese	Without Manganese
Hydrocarbons	0.255	0.265
Carbon Monoxide	4.983	4.985
Nitrogen Oxides	0.913	0.932

Thus, data obtained for Australian vehicles are consistent with the previously discussed data -- except for EPA's 1991 testing of a Dodge Dynasty. That is, regardless of base fuel, the HiTEC 3000 fuel additive has no instantaneous effect on tailpipe emissions.

SUMMARY

Based on the data noted above, there is no reasonable basis on which to conclude that HiTEC 3000 may have fuel specific effects on gaseous emissions, instantaneous or otherwise. The testing completed by EPA in 1991 on a single Dodge Dynasty is wholly inconsistent with testing completed by EPA on a different vehicle of the same model in 1990 (as well

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[3] Test Report -- Emission Testing of Australian Vehicles Using Ethyl MMT Antiknock Compound, prepared by J. M. McChesney, Ethyl Petroleum Additives, St. Louis, Missouri, December 1988 (see Attachment 3).

as vehicles from <u>five other models</u>), CRC testing completed in 1977 using basically the same test fuel as that used by EPA in 1991, and testing of Australian vehicles completed by Ethyl in 1986.

RLR/chw

Attachments (3)

RED SUMM 3Y 6/21/91

MFR	VEHICLE ID	1991 DODGE DYNASTY 3.3L V6 PFI	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DYNO
20 CHRY	RED BRUCE	1B3XC46R5MD204599	91	8.9	3375	18.0	6.4	D007

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODO. MILES	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emiss.	Base Fuel	Filter Prim.	Number Sec.	AMBT °F	BARO In. Hg	SPEC HUMID
912319	3/13/91	21	FTP	4066	0.350	2.703	423.9	0.573	20.6	0.012	N		IND	855	856	73.5	28.90	49.7
912320	3/14/91	21	FTP	4148	0.330	2.532	425.9	0.491	20.5	0.005	N		IND	869	870	73.5	29.00	52.2
912321	3/15/91	21	FTP	4231	0.358	2.496	428.2	0.575	20.4	0.030	Y		IND	889	890	73.5	29.35	48.7
912322	3/19/91	21	FTP	4321	0.378	2.579	417.4	0.644	20.9	0.065	Y		IND	903	904	73.5	28.92	52.4
912323	3/20/91	21	FTP	4403	0.398	2.511	414.4	0.687	21.1	0.083	Y		IND	917	918	73.5	29.06	59.5
912456	3/21/91	21	FTP	4485	0.400	2.601	406.8	0.660	21.4	0.087	Y		IND	923	924	72.5	28.81	58.2
912457	3/26/91	21	FTP	4557	0.432	2.663	411.4	0.738	21.2	0.127	Y		IND	937	938	73.5	28.95	57.5
912458	3/28/91	21	FTP	4872	0.453	2.989	405.8	0.705	21.4	0.082	Y		IND	951	952	72.5	28.67	44.5
912459	4/1/91	21	FTP	5227	0.459	2.981	406.7	0.781	21.4	0.131	Y		IND	959	960	72.5	29.09	45.5
912460	4/2/91	21	FTP	5531	0.423	3.028	407.7	0.745	21.3	0.093	Y		IND	969	970	73.5	29.41	44.2
912672	4/3/91	21	FTP	5781	0.449	3.110	412.7	0.721	21.1	0.118	Y		IND	977	978	72.5	29.52	44.9
912673	4/4/91	21	FTP	5854	0.306	2.291	413.3	0.457	21.2	0.010	N		IND	985	986	73.5	29.35	46.9
912674	4/23/91	21	FTP	5936	0.325	2.412	398.4	0.482	21.9	0.016	N		IND	1029	1030	75.5	28.70	51.8
913205	4/28/91	21	FTP	5991	0.308	2.265	408.2	0.511	21.5	0.005	N		IND	1039	1040	75.5	29.10	50.5
913365	5/9/91	21	FTP	7430	0.381	2.639	407.0	0.535	21.4	0.006	Y		INEEE	1077	1078	75.0	29.31	52.8
913480	5/14/91	21	FTP	7512	0.569	3.103	399.3	0.998	21.8	0.095	Y		IND	1091	1092	74.5	28.90	45.8
913491	5/17/91	21	FTP	7782	0.426	2.709	406.8	0.629	21.4	0.080	Y		IND	1103	1104	74.5	28.90	48.2
913492	5/23/91	21	FTP	8152	0.451	3.543	396.5	0.774	21.9	0.075	Y		Com/Reg	1119	1120	74.5	29.19	48.1
913535	5/24/91	21	FTP	8214	0.462	3.467	396.8	0.877	21.8	0.078	Y		Com/Reg	1125	1126	74.5	29.10	45.5
913536	5/25/91	21	FTP	8346	0.415	2.759	394.9	0.775	22.0	0.035	N		Com/Reg	1131	1132	74.5	29.05	46.7
913537	5/30/91	21	FTP	8435	0.437	2.700	391.1	0.834	22.3	0.052	N		Com/Reg	1139	1140	74.8	28.81	43.9
913538	5/31/91	21	FTP	8567	0.477	4.184	391.6	0.876	22.1	0.112	Y		Com/Reg	1155	1156	74.5	28.86	46.6
914015	6/13/91	21	FTP	8638	0.381	3.494	398.5	0.573	21.8	0.032	Y		IND	1197	1198	74.5	29.21	44.8
914016	6/14/91	21	FTP	8720	0.345	2.367	401.7	0.528	21.7	0.016	Y		IND	1207	1208	74.5	29.13	46.5
914067	6/18/91	21	FTP	9232	0.449	3.616	389.9	0.835	22.2	0.068	Y		IND	1223	1224	75.5	29.12	48.2
914068	6/19/91	21	FTP	9358	0.441	3.325	395.6	0.891	21.9	0.067	Y		IND	1231	1232	75.5	29.16	44.6

NOTE: Particulate tunnel cleaned on 3/22/91 and after 4/26/91

RED SUMMA..Y 6/21/91

MFR	VEHICLE ID	1991 DODGE DYNASTY 3.3L V6 PR	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DYNO
20 CHRY	RED BRUCE	1B3XC46R5MD204599	91	6.9	3375	16.0	6.4	D007

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODO. MILES	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emiss.	Base Fuel	Filter Prim.	Number Sec.	AMBT °F	BAROM In. Hg	SPEC HUMID
912324	3/13/91	21	HWFE	4077	0.061	0.544	272.9	0.118	32.2	0.019	N		IND	857	858	73.5	28.89	50.5
912325	3/14/91	21	HWFE	4160	0.045	0.417	273.7	0.151	32.1	0.002	N		IND	871	872	73.5	29.01	53.2
912326	3/15/91	21	HWFE	4242	0.043	0.336	274.1	0.100	32.2	0.043	Y		IND	891	892	73.2	29.35	47.8
912327	3/19/91	21	HWFE	4332	0.042	0.364	266.6	0.118	32.8	0.076	Y		IND	905	906	73.5	28.88	53.4
912328	3/20/91	21	HWFE	4414	0.038	0.352	268.5	0.131	33.0	0.089	Y		IND	919	920	73.1	29.04	57.9
912461	3/21/91	21	HWFE	4498	0.040	0.367	263.3	0.102	33.5	0.094	Y		IND	925	926	73.5	28.79	55.7
912463	3/26/91	21	HWFE	4568	0.040	0.395	261.4	0.133	33.8	0.114	Y		IND	939	940	73.0	28.90	58.7
912462	3/28/91	21	HWFE	4883	0.038	0.424	259.7	0.108	33.9	0.109	Y		IND	953	954	72.5	28.70	43.6
912465	4/1/91	21	HWFE	5238	0.044	0.452	259.7	0.142	33.9	0.127	Y		IND	967	968	72.5	29.13	45.7
912464	4/2/91	21	HWFE	5542	0.047	0.473	264.9	0.128	33.2	0.102	Y		IND	971	972	73.0	29.45	44.1
912675	4/3/91	21	HWFE	5792	0.052	0.465	266.4	0.131	33.1	0.111	Y		IND	979	980	72.8	29.53	45.4
912676	4/4/91	21	HWFE	5865	0.046	0.522	265.9	0.119	33.1	0.015	N		IND	987	988	73.5	29.32	47.9
912677	4/23/91	21	HWFE	5947	0.041	0.509	262.5	0.096	33.5	0.010	N		IND	1031	1032	75.0	28.70	50.6
913178	4/26/91	21	HWFE	6002	0.048	0.623	260.8	0.118	33.7	0.003	N		IND	1041	1042	75.0	29.11	51.0
913366	5/9/91	21	HWFE	7441	0.059	0.770	258.7	0.122	33.9	0.004	Y		WEEE	1079	1080	74.7	29.33	54.8
913481	5/14/91	21	HWFE	7523	0.049	0.816	257.7	0.158	34.0	0.151	Y		IND	1093	1094	74.5	28.90	45.0
913493	5/17/91	21	HWFE	7793	0.039	0.869	256.6	0.093	34.2	0.085	Y		IND	1105	1106	74.5	28.90	47.6
913650	5/17/91	21	HWFE	7902	0.034	0.511	257.8	0.086	34.1	0.010	N		IND	1109	1110	74.5	28.97	47.5
913494	5/23/91	21	HWFE	8163	0.053	0.902	254.8	0.170	34.4	0.082	Y		Com/Reg	1121	1122	74.2	29.20	48.3
913539	5/24/91	21	HWFE	8225	0.048	0.857	255.7	0.198	34.3	0.099	Y		Com/Reg	1127	1128	74.5	29.10	48.4
913540	5/25/91	21	HWFE	8357	0.046	0.600	253.5	0.190	34.8	0.035	N		Com/Reg	1133	1134	74.5	29.03	46.0
913542	5/30/91	21	HWFE	8446	0.049	0.746	255.1	0.181	34.4	0.056	N		Com/Reg	1141	1142	74.5	28.79	43.4
913541	5/31/91	21	HWFE	8578	0.044	0.594	254.0	0.213	34.6	0.086	Y		Com/Reg	1157	1158	74.8	28.68	46.8
914017	6/13/91	21	HWFE	8649	0.049	0.858	259.2	0.144	33.9	0.041	Y		IND	1199	1200	74.5	29.21	48.2
914018	6/14/91	21	HWFE	8732	0.043	0.582	259.2	0.015	33.9	0.026	Y		IND	1209	1210	75.0	29.11	50.1
914069	6/18/91	21	HWFE	9285	0.036	0.472	249.4	0.097	35.3	0.065	Y		IND	1225	1226	75.2	29.10	44.3
914070	6/19/91	21	HWFE	9369	0.040	0.693	255.1	0.126	34.5	0.089	Y		IND	1233	1234	75.5	29.16	44.6

NOTE: Particulate tunnel cleaned on 3/22/91 and after 4/26/91

RED SUMMA / 6/21/91

MFR	VEHICLE ID	1991 DODGE DYNASTY 3.3L V6 PFI	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DYNO
20 CHRY	RED BRUCE	1B3XC46R5MD204599	91	6.9	3375	18.0	6.4	D007

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODO. MILES	HC g/ml	CO g/ml	CO2 g/ml	NOX g/ml	MPG	PART g/ml	Mn Yes/No	Mn % Emiss.	Base Fuel	Filter Prim.	Number Sec.	AMBT °F	BAROM In. Hg	SPEC HUMID
912330	3/14/91	21	NYCC	4221	0.250	2.938	845.3	1.084	10.4	0.011	N		IND	873	874	74.0	29.01	53.2
912331	3/15/91	21	NYCC	4303	0.393	4.054	847.2	1.262	10.3	0.019	Y		IND	893	894	73.5	29.35	46.9
912332	3/19/91	21	NYCC	4393	0.501	4.115	842.9	1.365	10.4	0.024	Y		IND	907	908	73.4	28.89	52.4
912333	3/20/91	21	NYCC	4476	0.527	3.241	815.2	1.334	10.7	0.056	Y		IND	921	922	73.5	29.04	55.2
912466	3/21/91	21	NYCC	4547	0.589	3.550	811.2	1.384	10.8	0.069	Y		IND	927	928	72.5	28.81	54.6
912467	3/26/91	21	NYCC	4620	0.652	4.893	817.0	1.311	10.7	0.168	Y		IND	941	942	72.5	28.82	60.0
912468	3/28/91	21	NYCC	4924	0.658	4.368	811.3	1.348	10.8	0.134	Y		IND	955	956	72.5	28.70	45.3
912469	4/1/91	21	NYCC	5279	0.727	3.237	816.8	1.054	10.7	0.088	Y		IND	963	964	72.5	29.09	45.5
912470	4/2/91	21	NYCC	5613	0.587	4.581	816.8	1.590	10.7	0.102	Y		IND	973	974	73.5	29.45	45.0
912678	4/3/91	21	NYCC	5844	0.659	3.730	826.8	1.457	10.6	0.160	Y		IND	981	982	72.5	29.53	45.7
912679	4/4/91	21	NYCC	5926	0.269	2.123	812.5	0.958	10.9	0.009	N		IND	989	990	73.5	29.32	47.9
913179	4/26/91	21	NYCC	6063	0.236	2.205	718.9	0.992	12.2	0.018	N		IND	1043	1044	75.0	29.11	51.0
913871	5/9/91	21	NYCC	7502	0.390	2.751	809.5	1.069	10.8	0.011	Y		H/EEE	1081	1082	74.5	29.33	52.6
913482	5/14/91	21	NYCC	7583	1.471	4.172	790.8	2.099	11.0	0.257	Y		IND	1095	1096	74.5	28.90	43.9
913495	5/17/91	21	NYCC	7804	0.712	2.699	794.3	1.338	11.0	0.078	Y		IND	1107	1108	74.5	28.90	46.2
913496	5/23/91	21	NYCC	8204	1.072	7.780	806.3	1.656	10.7	0.077	Y		Com/Reg	1123	1124	74.5	29.20	46.8
913543	5/24/91	21	NYCC	8268	1.041	5.322	786.2	2.002	11.1	0.079	Y		Com/Reg	1129	1130	74.5	29.08	52.3
913544	5/25/91	21	NYCC	8418	0.597	4.023	777.0	1.940	11.2	0.030	N		Com/Reg	1035	1136	74.5	29.02	48.4
913545	5/30/91	21	NYCC	8507	1.048	6.630	767.8	1.744	11.3	0.128	N		Com/Reg	1143	1144	74.5	28.82	53.1
913546	5/31/91	21	NYCC	8628	0.530	6.871	775.1	1.411	11.2	0.085	Y		Com/Reg	1159	1160	74.5	28.88	48.8
914019	6/13/91	21	NYCC	8710	0.524	2.857	789.8	1.184	11.1	0.028	Y		IND	1201	1202	74.5	29.21	48.2
914020	6/14/91	21	NYCC	8792	0.371	1.999	704.4	1.362	12.5	0.009	Y		IND	1211	1212	75.2	29.11	52.0
914071	6/18/91	21	NYCC	9348	0.530	2.287	688.4	1.302	12.7	0.036	Y		IND	1227	1228	75.5	29.10	43.8
914072	6/19/91	21	NYCC	9419	0.941	3.214	766.5	1.641	11.4	0.049	Y		IND	1235	1236	75.0	29.16	44.2

NOTE: Particulate tunnel cleaned on 3/22/91 and after 4/26/91

TABLE XV

INSTANTANEOUS EFFECT OF MMT ON HYDROCARBON EMISSIONS

Test Mileage	MMT in Mileage Accumulation Fuel	No. of Cars	MMT in Indolene Test Fuel	Emission Source	HC Emissions, g/Mile	ΔHC	Significant at What Confidence Level?, %
0.3K	1/32 MMT	14	1/32 MMT 0	Engine	2.79 2.86	-0.07	90
			1/32 MMT 0	Tail Pipe	0.28 0.29	-0.01	10
	1/16 MMT	16	1/16 MMT 0	Engine	2.11 2.09	0.02	33
			1/16 MMT 0	Tail Pipe	0.30 0.34	-0.04	23
22.5K	1/32 MMT	18	1/32 MMT 0	Engine	2.09 2.14	-0.05	81
			1/32 MMT 0	Tail Pipe	0.41 0.41	-0.00	13
	1/16 MMT	18	1/16 MMT 0	Engine	2.25 2.18	0.07	99
			1/16 MMT 0	Tail Pipe	0.46 0.45	0.01	74

ATTACHMENT 2